CONSTRUCTION PROCEDURE

Used By

CALIFORNIA SHIPBUILDING CORPORATION

In the Construction of

U. S. M. C. TYPE EC 2-S-C1 CARGO VESSELS

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THE PRODUCTION RECORDS attained in this yard are the result of the cooperative efforts of a great many men in all the departments of the shipyard. The information presented in this book is based on the experience of the men in the field who are building these ships.

The book was prepared primarily to record and standardize construction procedures developed at Calship. Because many of the key personnel at Marinship were closely allied with these methods and contributed to their development at Calship, it is hoped that this book may serve as a reference handbook in the establishment of procedures at Marinship. The methods described are practical answers to the problem of fast production. They are not claimed to be the best possible answers, and undoubtedly they can and will be improved at both yards.

INTRODUCTION

The California Shipbuilding Corporation plant was designed and built to construct cargo vessels rapidly. With other yards on the east and west coast, it engaged in the construction of a large fleet of so-called emergency ships for the Maritime Commission. These ships, while reasonably simple in construction, retain all of the necessary design features of efficient cargo carriers, with comfortable and attractive living accommodations for officers and crew and with all of the necessary essentials of a good cargo ship.

The success of the yard in constructing these ships may be judged by the fact that in June, 1942, sixteen months after yard construction was started, the yard had increased its rate of production of ships to the point where it broke all shipbuilding records in World War No. 2 by launching 11 ships and delivering 15 ships in one month.

The hull of the emergency type ships was designed for subassembly in large units, and the shipyard of the California Shipbuilding Corporation was laid out to take full advantage of the speed thus made possible. Because of the importance of subassembly operations in the success of the yard, it has seemed advisable to bring together in a simple form a description of yard operations. This book describes in detail the methods used in fabrication, assembly, and erection of an EC-2 cargo vessel at the yard of the California Shipbuilding Corporation.

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SUB-ASSEMBLY—Continued

GENERAL DESCRIPTION OF EC-2 LIBERTY SHIP

The United States Maritime Commission design EC2-S-C1 cargo vessel, known as the Liberty Ship, is a single screw steamer with a length between perpendiculars of 416 feet, a length over all of 441′ 6″, a maximum beam of 57 feet, and a molded depth to the upper deck of 37′ 4″. It has a displacement to the load waterline of 14,100 tons and a deadweight carrying capacity of 10,800 tons.

The vessel has two complete decks and a flat forward of the forepeak bulkhead between these decks. It has a raked stem with a paravane forefoot and an elliptical cruiser stern. It is subdivided by eight main transverse bulkheads watertight to the upper deck, providing five cargo holds. Further subdivision provides deep tanks in No. 1 and No. 4 holds for water ballast, oil, or dry cargo. The upper deck has both sheer and camber, and the vessel is of pleasing appearance.

The main propelling machinery is located in a single machinery space amidship and consists of a three cylinder triple expansion steam engine developing about 2500 I.H.P. at 76 R.P.M. Steam is supplied by two water tube boilers at 220 pounds per square inch gauge pressure and 450° F. total temperature at the superheater outlet. The ship has a sustained speed under sea conditions of better than 11.5 knots. The electrical system consists of three 20 KW reciprocating steam engine driven generators.

The ship is provided with three cargo masts and one signal mast. Ten wooden booms of 5 ton capacity and two steel booms are provided. The forward steel boom is of 50 ton capacity and the after steel boom of 15 ton capacity. All cargo winches are steam operated.

Quarters for gunners and a hospital are provided in the after deck house. Accommodations for all other crew and for all officers are provided in the midship deck house. All living quarters are steam heated and naturally ventilated, and showers, lavatories, and such, are provided with hot and cold running water.

The structural design of the EC-2 cargo vessel is distinguished by two features in particular—the extensive use of welded construction and the structural arrangement allowing the hull to be broken into large sub-assemblies. It is practically an all welded structure, the one exception being the connection of the side frames to the shell plating between the tank top and the upper deck. These channel frames are riveted to the shell, utilizing about 23,000 rivets per ship. All seams and butts of shell, decks, and bulkheads are butt welded and present a flush smooth surface. All transverse floors, bulkhead stiffeners, deck beams and girders, and transverse side frames in the fore and after peaks and in the deep tanks are welded. Welding is thus an extremely vital function in this yard.

The structure was designed with an eye to the possibility of being sub-assembled in large units before final assembly on the ways. The double bottom and decks particularly were so arranged structurally as to allow their natural division into large units. This yard has utilized these units wherever possible and has taken advantage very fully of the benefits of assembling these units on a large level assembly skid where the units may be turned and a maximum amount of down-hand welding may be obtained. The yard has in fact gone further than most other yards in this respect and pioneered in the sub-assembly of the shell of the ship in large units. To simplify the erection of these shell sub-assemblies, the yard modified the original shell expansion, which provided the usual shift of butts, and lined up in one vertical line the butts of the shell plates in all strakes above the bilge.

Aside from the two features mentioned above, the structure is of conventional merchant ship construction designed to American Bureau of Shipping requirements. Frames are spaced 30 inches throughout the midship region of the ship with reduced spacing to 27 and 24 inches at the forward and after ends. Double bottom construction is used, and in the interest of simplification there is no inclined margin plate from tank top to bilge, but the tank top plating runs horizontally from shell to shell. The framing below the tank top consists of solid and open transverse floors welded to shell and tank top in the first 55 vessels being built at this yard, and solid floors throughout the next 109 vessels. There is a solid continuous vertical keel and there are several intercostal longitudinals. The side frames consist of channels bracketed to the tank top and to the second and upper deck beams, and riveted to the shell in the midship region. In the peaks the frames are bulb angles welded to the shell.

The deck is transversely framed with deep transverse girders at the hatch ends and longitudinal girders at the hatch sides. Deck houses and mast houses are of all welded construction. The upper deck and deck houses have sheer forward and aft and straight line camber, and the second deck has sheer only at the after end and no camber.

The ship is, all in all, an efficient cargo carrier of pleasing appearance and sound design and construction. It lacks none of the essentials of a good modern ship, fulfills all of the requirements of the various regulatory bodies, and can safely and proudly carry the tradition of the sea and of American shipbuilding out to the far corners of the earth.

Layout of the Yard

The shipyard is located along Cerritos Channel on the north side of Terminal Island on a tract of land approximately 1600 feet wide by 4000 feet long. Fourteen ways and ten berths at the outfitting docks are spaced along the channel side of the yard and a highway bounds the southern edge. The very temperate climate makes it feasible to do all sub-assembling in the open air and provide only a roof and two short end walls on the shop.

The yard was designed for a straight line flow of material from the cars to the hull. Incoming material enters at the south and flows north through storage yards, shops, skids, and ways to the finished ship. The hulls are launched lengthwise into Cerritos Channel. The total width of water to the opposite shore varies from 1200 to 1500 feet and the minimum depth is about 20 feet.

The incoming steel is partly classified at receiving tracks before it enters the steel yard, to eliminate excessive crane travel while distributing the contents of a car. An attempt is also being made to have the steel companies put all the same size steel in one car for the same reason. In general, steel is stored as close as possible to the particular shop bay in which it will be used.

Since only one type of ship is being constructed and plates are routed to the shop for several hulls at a time, it is economical to store the plates flat. Plates and shapes are picked up by a gantry crane that travels the full length of the yard on the side next to the shop. There is a considerable saving in crane lifts when the crane can pick up at one time all plates of one size instead of picking up the plates individually from a vertical plate storage. The crane either places the steel directly in the bay, or loads it onto cars or trucks that are unloaded at the desired bay. Steel passes through the bays of the shop from south to north. At the north end of each bay, the fabricated steel is either shipped directly to skid or hull or to storage to be used later on the skids and hull, or it is pre-assembled into the items that the shop prepares for the skids or ways.

The capacity of the plate shop has gradually been stepped up until now it can handle well over 1,000 tons of steel per day.

The distance between the highway and the channel is limited, and the space between the north side of the shop and the ends of the ways is fairly narrow. In this space, there are special sub-assembly skids, a craneway and roads, the skids at each way, and storage room between the skid and the way. However, since there is very little storage area at the sub-assembly skids, the skids could not always take the steel as fast as the shop fabricated it. To overcome the congestion between the shops and skids, a storage area was provided at the east end of the yard to which most of the fabricated steel is sent and from which the skids draw it as they need it.

Storage is by commodities—thus all frames with the same number are stored together. Occasionally, if there are a number of small pieces to a section, such as stiffeners, they are bundled together, and the bundle of stiffeners is the commodity unit.

Also as production has increased, the traffic on the craneway and the road under the cranes has become very heavy, and as speed increases, the skids are lacking the area to keep up with the hulls. To overcome this lack of space, work has been started on a program that will provide a large sub-assembly building at the east end of the yard adjacent to the fabricated steel storage area. Also as part of this program, the length of the superstructure sub-assembly skid west of way No. 1 has already been extended. The additional sub-assembly area will balance the skids with the ways and will make possible the removal of part of the skids between the shop and the craneway, to provide additional trucking area and freer access to all of the skids.

When the sub-assembly building is available, the bulkier sections that are difficult to transport will be constructed at each way skid, and second deck at the east skid, the superstructure at the west skid, and practically all of the remainder at the new building.

Gantry cranes with a capacity of 21 tons at 53′ 6″ radius cover all parts of the hull. There is a crane for each way and, like the skids and roadway, this number was sufficient for the original capacity of the yard. But now that actual production has considerably exceeded the designed production, and will increase even more, additional crane capacity is required. A second crane has been ordered for each of the 14 ways, and these cranes will be available within the next few months.

Outfitting material is stored in a large open storage area at the west end of the yard southwest of the outfitting docks. Equipment and supplies are stored in warehouses just south of the outfitting docks. Gantry cranes similar to those at the ways service the outfitting docks.

A part of the yard area has been devoted to an extensive training program which was undertaken in order to provide a reserve of skilled labor. This program has been quite successful, and its principal features will be described later.

Transportation

It is obvious that if the shop fabricates 1000 tons of steel a day, this amount of steel must be loaded from cars into the steel yard, handled from the yard to the shop, taken from the shop to storage or to the skids, and taken from the skids either to the ways or to storage. Thus for every ton fabricated, several tons must be picked up and transported from one place to another. The problem of transporting several thousand tons of steel a day, plus all of the machinery, equipment, and the multitude of small items necessary for outfitting these vessels is thus a very important problem and indicates the vital part that transportation plays in the functioning of the yard.

The gantry cranes and the truck whirly cranes contribute very largely to this picture. There are numerous railroad spurs serving the yard areas and all of the open areas of the yard are paved with asphalt, enabling the extensive use of trucks throughout the yard.

Facilities

All of the power, water, gas, oxygen, and compressed air for the yard is distributed underground, leaving the working area completely free of obstructions.

Power is received at 33,000 volts and distributed at 2200, 440, and 110 volts. The compressors use 2200 volt synchronous motors. All welding outlets are 440 volts, and lighting is distributed at 110 volts. The constant potential welding system generators under the ways are driven by 2200 volt synchronous motors, and the current is distributed to the ways at 64 volts. Unionmelt welding transformers are supplied by numerous 440 volt outlets at the skids.

All of the acetylene is manufactured at the yard in carbide generators and piped throughout the yard at 14 lb. pressure. The gas mains are protected by rupture discs. Liquid oxygen is received in trucks and stored in the liquid form. The oxygen distribution system parallels the gas system and it operates at 125-150 lb. pressure.

The air compressors are located at the east end of the yard, and they have a capacity of 10,000 cfm which is supplemented by 2730 cfm from portable compressors. An additional 4000 cfm of capacity is now being installed at the west end near the outfitting docks to improve the pressure in that area. With the additional capacity, the pressure should hold at 110 lbs. in the mains, and the portable compressors will be retired.

WELDING

One of the most important single operations in the assembly of each hull is the welding. All of the shop pre-assembly, most of the skid sub-assembly, and practically all of the hull assembly on the ways is done by means of welding.

Two important factors in connection with welded construction have influenced the whole assembly operation. The first of these is the economy of down-hand or flat position welding. That this economy is appreciable is demonstrated by the fact that the average welder on the assembly skids produces twice as much welding footage per day as the welder on the ways. This is partly due to the relative accessibility of the work, but the principal influence is that of welding position.

The second factor is that proper welding procedure is necessary to avoid distortion. For instance, the order in which the members are welded and the means by which they are held together largely determine their freedom from distortion.

Since welding is so important a feature in the assembly of the hull, a description of the welding equipment and of the principal welding procedures has been included. Then also in the sections devoted to assembly operations, the importance of the welding procedure is emphasized.

All welding supervisors prepare a daily report covering total lineal footage deposited. Based on these reports, the following figures have been computed. It is realized that for various reasons the totals arrived at are somewhat higher than the quantities estimated from plans. But this fact has no effect on the proportionate distribution to various areas, and the figures are consistent from ship to ship.

The approximate total lineal footage of welding in each hull is 255,000 feet distributed as follows:

Plate Shop	30,000 lineal feet
Assembly	76,000 lineal feet
Unionmelt on Sub-Assembly	33,000 lineal feet
Shipways	106,000 lineal feet
Hull Welding at Outfitting	10,000 lineal feet
Total	255,000 lineal feet

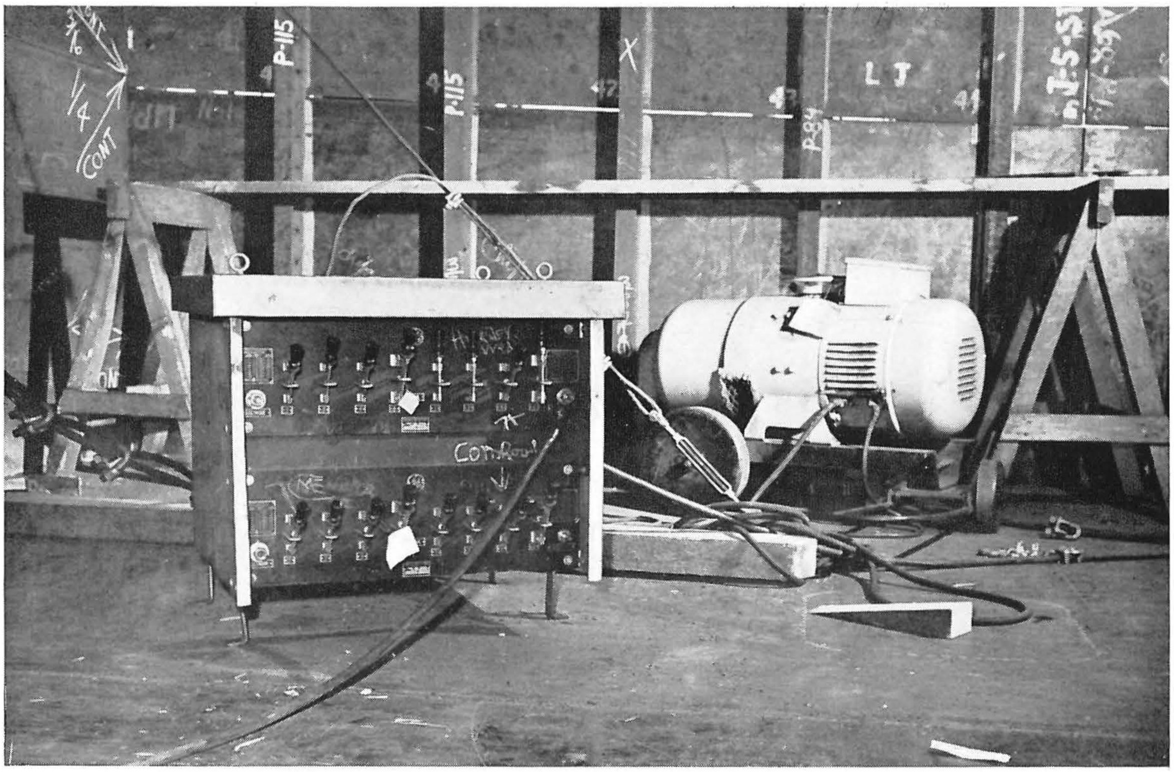
By the time that the assembly on the ways has started, 139,000 output of a total of 255,000 feet or 54% have been welded. The greater part of the welding is done by hand but when two plates are to be welded together in the flat position and the edges can be accurately cut, the welding is done by Linde unionmelt welding machines.

EQUIPMENT FOR MANUAL WELDING

The yard is equipped with approximately 1700 manual welding leads, 1150 of which are single operator D. C. portable welding generators and 550 of which are resistor units taken from a constant potential distribution system. The constant potential system consists of twenty-one 1500 ampere G. E. generators, 64 volts D. C. driven by 2200 volt synchronous motors. The twenty-one generators are located in four stations built beneath the shipways as follows:

6 generators under way No. 2
6 generators under Way No. 7
5 generators under Way No. 10
4 generators under Way No. 13

Each welding generator will supply 18 welders or 35 tackers, and as the equipment is used mainly for tacking and light production welding, the number of men working from the C. P. system is approximately 550 per shift.



Four operator constant potential unit and single operator machine.

The single operator machines which are General Electric, Lincoln Electric, Harnischfeger, Wilson and Hobart, in the order of predominance, are distributed as follows:

	Size of Machine			
Location	400 Amp.	300 Amp.	200 Amp.	Total
Plate Shop	33	69	1	103
Assembly	40	221	5	266
Ways 1-7	37	108	75	220
Ways 8-14	19	129	72	220
Outfitting Hulls	12	85	105	202
Outfitting Pipe	0	30	47	77
Pipe Shops	0	27	7	34
Sheet Metal	0	0	8	8
Miscellaneous	1	4	7	12
Total	142	673	327	1142

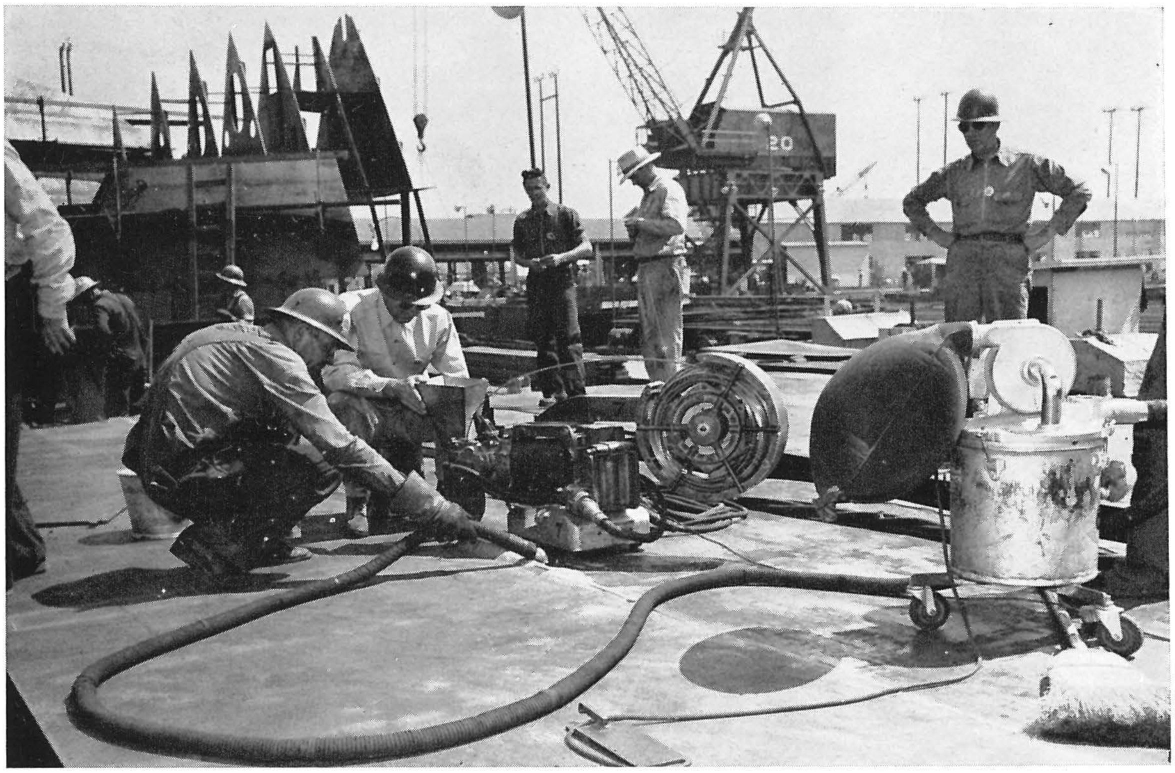
Approximately 4 per cent of the portable single operator machines usually are out of service for maintenance and repairs, leaving 1100 machines available at all times.

In addition to the above equipment, 350 portable single operator machines of 300 ampere capacity are on order, as well as 50 alternating current single operator machines for the plate shop and 100 single operator 200 ampere D.C. machines for the welding school.

Practically all of the 200 amphere single operator machines are mounted three to a hoist-skid, and the additional 300 amphere machines are to be mounted four to a hoist-skid. Eventually we plan to have the majority of the machines either on hoist-skips or on permanent platforms on the scaffolding.

Unionmelt Welding Equipment

The yard has in operation 19 U-type Linde unionmelt automatic welding machines and two S-type machines. The U-type machines are heavy duty and use coiled rod from 5/32″ to ¼″ diameter. The S-type machines use straight rod from ⅛″ to 3/16″ in diameter and 16′ in length. Twenty-one 1500 ampere welding transformers made by Glenn Roberts are used to furnish welding current from a 440 volt distribution system. The welding transformers are housed in enclosed hoist-skips which are large enough to carry a supply of rod and of unionmelt flux as well as the unionmelt machine when the crane moves the skip to a new location.



Unionmelt Welding Plates on Skids

Each unionmelt machine is equipped with a portable suction unit to recover the unfused flux, which is mixed with new flux and used over again.

Five twin head unionmelt machines have been ordered for welding stiffeners to bulkheads and decks. These twin machines are designed to weld two fillets at one time, one fillet on each side of the stiffener, the machine being guided by and running on the stiffener.

Manual Welding Procedure

The manual welding on the skids is done principally with 300 ampere machines. On the shipways the greatest number of machines are 300 ampere, but there is a higher proportion of 200 ampere machines for tackers, overhead welding, and pipe welding. A description of each type of welding machine follows:

Constant Potential leads are not as satisfactory in general as the single operator machines, mainly because there is some interference between operators due to the voltage drop in the distribution of the total current through common bus-bar feeders. The Constant Potential leads are, however, quite satisfactory for tackers and others doing light welding such as "pick up" welding in tanks and the like.

200 ampere single operator machines are used for pipe welders on the ways and for tackers.

300 ampere single operator machines are most suitable for general ship welding in all positions as this size machine will cut down readily for 5/32" and 3/16" electrodes for vertical and overhead work and will also handle 7/32" and ¼" electrodes for most of the heavier flat position work.

400 ampere single operator machines are used to weld heavy flat position grooved work such as flat bottom seams and butts and deck to shell grooved seams. This work is done with ¼" and 5/16" electrodes.

When all of the machines on order have been received, the distribution of leads to a shipway for a 35 day erection schedule will be

200 Amp.	300 Amp.	400 Amp.	C.P.	Total
12	41	5	36	94

Some of the major points of yard procedure are

1. All welders are qualified according to specifications of the American Bureau of Shipping and the Bureau of Marine Inspection and Navigation.
2. Welding electrodes are purchased from vendors who have had their welding rod approved by the America Bureau of Shipping.
3. String beads are used for all butt welds and weaved beads are used for vertical fillets up to ⅜" in size.
4. Vertical and overhead welding is done with ⅛", 5/32", and 3/16" diameter all-position welding rods. Flat position work is done with 3/16", 7/32", ¼", and 5/16" diameter flat-position welding rods.
5. So far as is practical, welding on sub-assemblies is started at the center line of all sections and progresses symmetrically port and starboard as well as forward and aft.
6. Welding on the shipways progresses from midship forward and aft and is kept symmetrical port and starboard.
7. The shell seams and butts are welded in sequence, to complete all transverse butts before the longitudinal seams are welded past the butts.
8. Butt welds are back-chipped after the first side is welded, to provide a clean surface for welding the second side.
9. Manual welders tack welding seams for unionmelt welding must use all-position reverse polarity rod as porosity will result if straight polarity rod is blended with unionmelt welds.
10. All vertical welding is done up-hill with the exception of superstructure welds on plates 3/16" and less in thickness where down-hill welds are permitted.
11. Butt welds that are unsupported must be strongbacked for stiffness before welding is started.
12. The layout and size of the welding is clearly marked by welding layout men ahead of the welders.

Unionmelt Welding Procedure

The plate seams on the sub-assembly skids are all unionmelt welded because it is faster and the plate edges can be machine burned in the shop. At one time the seams between the completed deck sections on the ways were unionmelt welded, but it it has been found that these seams can be welded manually more economically due to the fact that the machine welds require more exact preparation, which is difficult to obtain under erection conditions and also because the unionmelt machines are not always readily available for moving aboard the hulls when required.

The principal rules for unionmelt welding are that

1. Fit up of square edge plate must be such that no gap between plate edges is greater than 1/16" for plates above ⅜" thick, and no opening between plate edges is greater than 1/32" for plates ⅜" thick or less—otherwise the puddle will break through the lower side.
2. Plate edges must be buffed or wire-brushed free from loose burning scale and rust to prevent gas pockets in the weld.

3. Seams must be perfectly dry, and if dampness exists, it is necessary to dry out the seams with a heating torch directly before welding to prevent gas pockets.

4. The sulphur content of the steel should not be much over 0.04% since sulphur cracks will result in welds made on material in which the sulphur content is higher.

5. Plates up to ⅝" thick are welded with square butting edges, using one pass of welding on the first side that penetrates 50% of the thickness and one pass on the second side that penetrates at least 60% of the plate thickness in order to unite the root of the two welds.

6. Plates heavier than ⅝" thick are grooved with a scarfing torch to ⅝" thickness before welding the second pass.

7. It is of the utmost importance that unionmelt operators run their machines with the weld beads centered on the seams. If the two passes are run with the heads "off-seam" 1/16" in opposite directions for a total of ⅛", the root of the two seams may not meet and a small unwelded zone results. In order to check that the operators are running their welds properly centered on the seams, all operators punch reference points at both ends of all straight seams so that after the weld is made the seam line can be measured from the reference points to check the weld for alignment. The operators also stamp an identification number on each seam welded.

8. All unionmelt machine settings are in accordance with approved settings made on test plates for each plate thickness. These test plates were made for the American Bureau of Shipping surveyors and approved by them before each thickness of plating was welded in production.

Typical unionmelt settings are

	First Pass			*Second Pass*		
	Amps.	*Volts*	*Speed*	*Amps.*	*Volts*	*Speed*
½" Plate Square Butt	700	33	22"/min.	750	35	20"/min.
⅝" Plate Square Butt	850	33	18"/min.	950	35	17"/min.
½" to 1⅛" Engine Bed Beveled	800	33	20"/min.	1000	33	17"/min.
¾" Plate Second Side Beveled ¼" Deep	900	33	16"/min.	1050	35	17"/min.

Welding Organization and Supervision

Manual welding is sub-divided into the following divisions:

1. Plate shop
2. Sub-Assembly
3. Ways 1 to 7
4. Ways 8 to 14
5. Outfitting
6. Pipe department
7. Training division

Each division is in charge of a welding superintendent who is held responsible to the welding engineer for the procedure, sequence, and general welding done in the division. All hiring or inter-division transfers of welders must clear through the welding engineer's office. A master file record of all welders showing the qualifications and service record of each welder is kept by the welding engineer's office.

Unionmelt welding is a part of the sub-assembly organization and is supervised by a superintendent.

At present the welding organization includes the following in round figures; of these men only 80%, approximately, work on any one day, the other 20% includes men on their day off and absentees.

Production welders	3200
Pipe welders	500
Tackers and trainees	1500
Students in Training	400
Welders' helpers	500
Foreman, leadmen, and supervisors	600
Total	6700

TRAINING AND QUALIFICATION OF WELDERS

Primary training of welders for Calship has been done mainly by the Defense Schools of the California state school system. These trainees are tested either at the testing station at 111 West C Street, Wilmington, or at the yard, and depending on their skill they are either assigned to do tack welding or given advanced training in the yard. A staff of 80 to 100 instructors is working in the yard to improve the skill of these partially trained welders. Production welders must pass the American Bureau of Shipping tests in order to qualify to work on the hulls or on pipe work. The American Bureau of Shipping certification is accepted by the Bureau of Marine Inspection and Navigation.

Rod Distribution Cabinet.

WELDING ROD DISTRIBUTION AND SALVAGE

Welding rod is distributed by the tool department. Rod is requisitioned from warehouse stock and delivered to rod cabinets and sub-tool rooms throughout the yard. All welders obtain their supply of rod at start of shift in rod cans, and at the end of the shift the cans are returned to distribution points with all unused rod and all rod stubs. This method of distribution prevents welders from leaving unused rod around where it may become damaged; also it keeps rod butts from being scattered around, and it tends to prompt welders to burn their butts to minimum length.

All damaged rod and stub ends are picked up by the yard labor crews and delivered to a salvage room where the rod is sorted over. Students and tackers use up the salvaged rod. A process of re-coating rod is being developed to use salvaged rod that has damaged coating.

SHRINKAGE

The shrinkage which accompanies welded construction is one of the problems that must be encountered and solved properly. There are two things which are done to meet the problem. One is to lay out and control welding deposit in the proper sequence to minimize shrinkage. The other is to make

the proper allowance in structural layout for the shrinkage which will occur in various structures so that the final dimensions will be correct and the various assemblies fit together. There are of course variables in the picture, one of the most important being the personal element. Experience has indicated various allowances in various places. The following cases are cited as typical examples:

There is a large amount of welding on the double bottoms and considerable shrinkage. The vertical keel shrinks about 1/32″ per frame space of 30″ while it is being welded on the skids, and the shop makes an allowance of 1/32″ in the spacing of each floor on the vertical keel. Thus in a 40 foot section there are 16 frame spaces, and the allowance is 16/32″ in the length of the keel. When the tank top layout is being made on the skids, an allowance of 1/32″ is made in the spacing on the tank top of the last 6 floors at each end for the 40 foot section and of the last 4 floors at each end for the the shorter sections. This allowance compensates for the tank top shrinkage during sub-assembly. In addition to the 1/32″ per floor allowance, an additional allowance of ½″ is made in the length of the keel after sub-assembly to compensate for the shrinkage of the whole section after it has been welded in place on the hull.

The A to F shell plates of the forepeak shrink ⅝″ while being welded, and an allowance is made in each of the five seams to compensate for this shrinkage. Then the second deck is reset to the proper height from the keel and welded in place.

EMPLOYEE TRAINING PROGRAM

Early in the operation of the yard, the scarcity of skilled labor made it advisable to institute a training program for unskilled employees. Under this training program, the available unskilled or partially trained labor can be hired and then converted to skilled journeymen while employed directly on production. The trainees are paid a slightly higher rate than that of a helper, and their training may take place on the hulls or on the very simple production items allotted to the school. All produc tion work done at the school is approved by the Maritime Commission, the American Bureau of Shipping, and the Bureau of Marine Inspection and Navigation.

Such a training program is economical for the employee and the employer, first because the employee is earning while he learns, and second because the employer receives skilled journeymen trained in the technique actually used in the yard. It has been found that the general instruction given at various defense schools outside the yard must be supplemented by training in the yard to cover technique used specifically in this yard.

To supplement this in-yard training program, which is on a production basis, the following additional courses are given by the training division: shipfitting, plate layout, blueprint reading, machine installation, pipefitting, and marine electrical installation. These courses are available to employees but are not given on company time. The instructors are certified by the State of California and are state employees, although they are selected and recommended by the company.

The in-yard training is mainly in four crafts: welding, burning, riveting, and chipping.

Welding Training Procedure

The first step in training welders is the selection of expert instructors. This is necessarily a highly important feature, for the quality of instruction has a direct bearing on the results accomplished. The instructor chosen for this work should have spent many years in practical electric arc welding either in steel ship construction or in some similar type of plate construction. He must also have a working knowledge of welding theory. The most important requisite, however, is that he is of such a personality as to be able to deal with and impart his knowledge to the trainee.

The preliminary procedure in instructing the trainee begins with acquainting him with his source of power and with the adjusting of the current on the welding machines so that he is able to increase or decrease the current to suit the size of the material and rod used. The instructor shows the trainee the proper angle of application of the welding rod and the proper length of arc.

The trainee is started out on flat plate and is under constant observation of the instructor so that he learns to control the flow of metal as it is deposited. The trainee is shown the proper way to clean his weld so that all slag is removed and, when one bead is laid on top of the preceding bead, a perfect weld is accomplished.

After becoming proficient on flat plate, the trainee is given similar instruction on vertical plate. After he progresses satisfactorily in the opinion of the instructor, he is given authority to run his test plates, which are machined and tested. When the trainee has successfully passed his vertical plate, he is taken out of the booth training and placed in production training.

Production welding by the trainees is done on such items as shaft tunnels, keel turnbuckle clamps, welding stands, bulwark brackets, cable racks, hatch batten wedge cleats, strongbacks, keel clamps, scaffold guard brackets, skips for salvage, and bracket braces for the ways. All of the production welding on the foregoing items is approved by inspectors before the material is removed from the training yard.

While on production work, the trainee is continually under the supervision of an instructor. When the instructor feels that the student has sufficiently advanced, he is assigned for his overhead plate test. Generally speaking, an instructor is assigned not more than ten trainees. It is found that an instructor, no matter how competent, cannot give proper attention to more than ten trainees during a shift.

When the student passes his final plate, he may then be transferred out of the school into production welding on the ways, skids, or the plate shop, consideration being given to the particular ability displayed by the trainee during his school period. As the trainees are transferred out of the school, they

are replaced by new hires who have had some preliminary welding training or by transfers from other departments within the yard who have had a similar background.

Burning Training Procedure

The burner school likewise is maintained on a production basis. The school is cutting all welding test plates as well as all clamps, wedges, saddles, etc., for the yard. A pool of burners is maintained in the school at all times and as men are transferred out into production as journeymen burners, they are replaced by trainees who have had some schooling in burning. Generally the trainee is transferred from some unskilled craft in the yard. The potential trainee is given a preliminary burning test at the school, and if it is apparent that he has the required ability, he is placed on the waiting list and is called in order as openings in the school become available.

The first step in instruction of the trainee is to acquaint him with the safety factors as applied to burning equipment. He is then instructed in the correct oxygen and acetylene pressures necessary for the size of the material to be cut. He is then instructed in the proper positions in which to place himself and his torch, so that he does not burn his fellow workmen with sparks or slag from his torch. After these preliminary steps, the trainee is then put on production work starting with light material, and as he progresses in efficiency he is assigned to more intricate work.

Chipping Training Procedure

The chipping training program is essentially the same as the burner school. Prospective chippers are taken from the various labor departments in the yard and are given preliminary instruction in the chipping school. Usually in a period of eight hours or less, they become sufficiently familiar with the chipping hammers and the various tools.

The first step in training the chipper trainee is to acquaint him with the various chipping hammers and tools that are used in this craft. The trainee is first assigned to work in a flat position on the training skid with a flat chisel. When in the opinion of the instructor the trainee has advanced sufficiently, he is assigned to vertical and overhead work with the V chisel.

In order to satisfy the demands of the yard for journeymen chippers, there are maintained in addition to the school, six utility crews of eight trainees for each shift. These trainees are assigned to production work on the ways and on the skids. The trainee is transferred from the school to these utility crews and when the instructor believes that he has developed into a journeyman chipper, the trainee is sent to the school for his final test where he is graded and then assigned to production work. The arrangement as outlined provides a pool of approximately 200 trained men in various classifications, available at all times.

Identically the same procedure is followed in training riveters as in the training of chippers.

Results of Program

The training program has contributed vitally to the success of the yard by supplying trained journeymen in the various crafts whenever the supply in the area is inadequate to man a program of this size and speed. The maximum number of men provided from this source in a month for the various trades are

Welders	600
Chippers	120
Riveters	10
Burners	250

In the first year of operation, approximately 10,000 men were provided in this manner. Obviously the contribution to the program has been appreciable.

PLATE AND STRUCTURAL SHOP

Very important in the pragram of rapid production of ships is the plate and structural shop, in which is fabricated practically all steel that goes into the hull. This shop has turned out more than 1000 tons of fabricated steel per day and is capable of as much as 1100 to 1200 tons per day. In addition to this, it contributes to the assembly program by pre-assembling small units such as shaft tunnels, hatch beams, etc. Obviously the design of this shop to insure maximum production was vitally important.

The shop consists of 10 bays, 75′ wide by 225′ long, running north and south, plus a shorter eleventh bay at the west end. Each bay is serviced by one or more 10 ton overhead bridge cranes. The material is fed in from the storage yard at the south end, is fabricated or pre-assembled, and then is delivered to the transfer area at the north end of the bays. Each bay has a fixed sequence of material to fabricate for each hull, and through experience and proper planning, the flow of material has been balanced to keep each bay busy. Taking advantage of climatic conditions, the shop bays are open at the ends, providing unobstructed areas the full width of each bay from steel storage yard to transfer area for movement of materials.

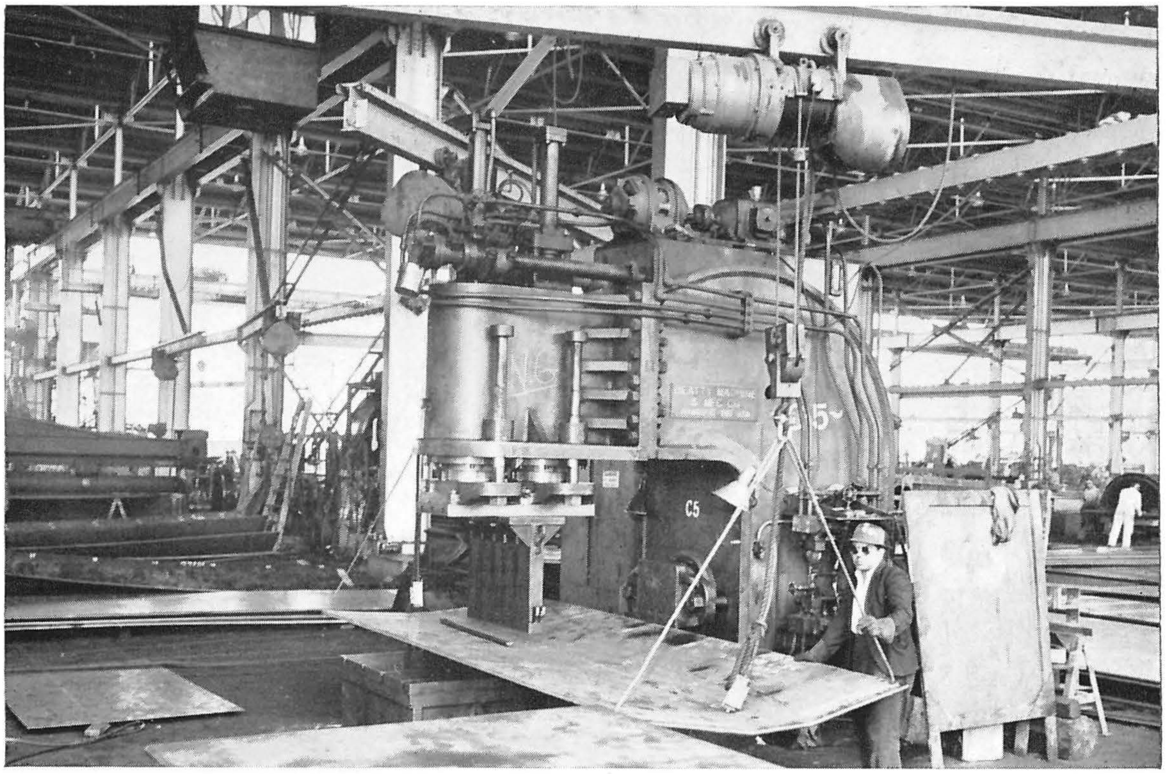
Looking Eastward from Bay 10 Along Center Aisle.

The paragraphs on the plate and structural shop which follow contain a general description of the fabrication by bays, a list of the equipment, a detailed description of the flame cutting equipment, a detailed description of the fabrication by flame cutting, and a description of the principal pre-assembled items.

General Description of Fabrication by Bays

All flame cutting, rolling, drilling, and pressing of shell plates, keel plates, and shaft tunnel plates are done in bays 1 and 2. The plates are cut by radiagraphs or by a Link Belt flame planer.

95-100



Pressing Flat Keel.

In bay 3 the tank top plates, deck plates, vertical keel plates, after deck house, and bulkhead plates are flame cut by the Link Belt flame cutter and by radiagraphs with steel straight edges. The shaft tunnels are assembled in this bay.

Tank top gussets, margin frames, after peak plates, and forepeak plates are flame cut with the travograph and the radiagraph in bay 4. The frame brackets are sheared and then partly trimmed with a hand torch.

All of the midship superstructure plates, after deep tank plates, and plates for the hatch end beams and longitudinal deck girders are cut in bay 5 by travograph or a radiagraph, and the hatch end beams and longitudinal deck girders are pre-assembled here.

About 50% of the solid floors and all of the intercostals are fabricated in bay 6, using a travograph for the floors and an oxygraph for the intercostals. The other 50% of the floors, including all those with stiffeners, are fabricated in bay 7 with a travograph. The gun platform plates are also fabricated in bay 7 with a radiagraph on a standard track.

At the south ends of bays 8 and 9 are located the shape furnaces and bending slabs where channels, angles, and other shapes are flanged and bent for frames and similar members of the hulls. The forepeak and afterpeak bulb angle frames are flame cut by radiagraphs, second deck brackets are welded to the main frames, and the upper deck brackets are welded to the 'tween deck frames.

All of the miscellaneous small details such as brackets, hatch covers, ventilating ducts, rigging, etc., have been grouped together and are fabricated in bays 10 and 11. These bays contain the small rolls, punches, shears, and presses necessary to handle small parts. Most of the burning of duplicate small parts is done on a planograph.

In addition to the main shop, skids have been set up at one side of the storage yard where all deck beams, bulkhead stiffeners, degaussing channels, and miscellaneous shapes are trimmed to length. Most of this material does not require any further treatment in the shop, and it is sent directly to the

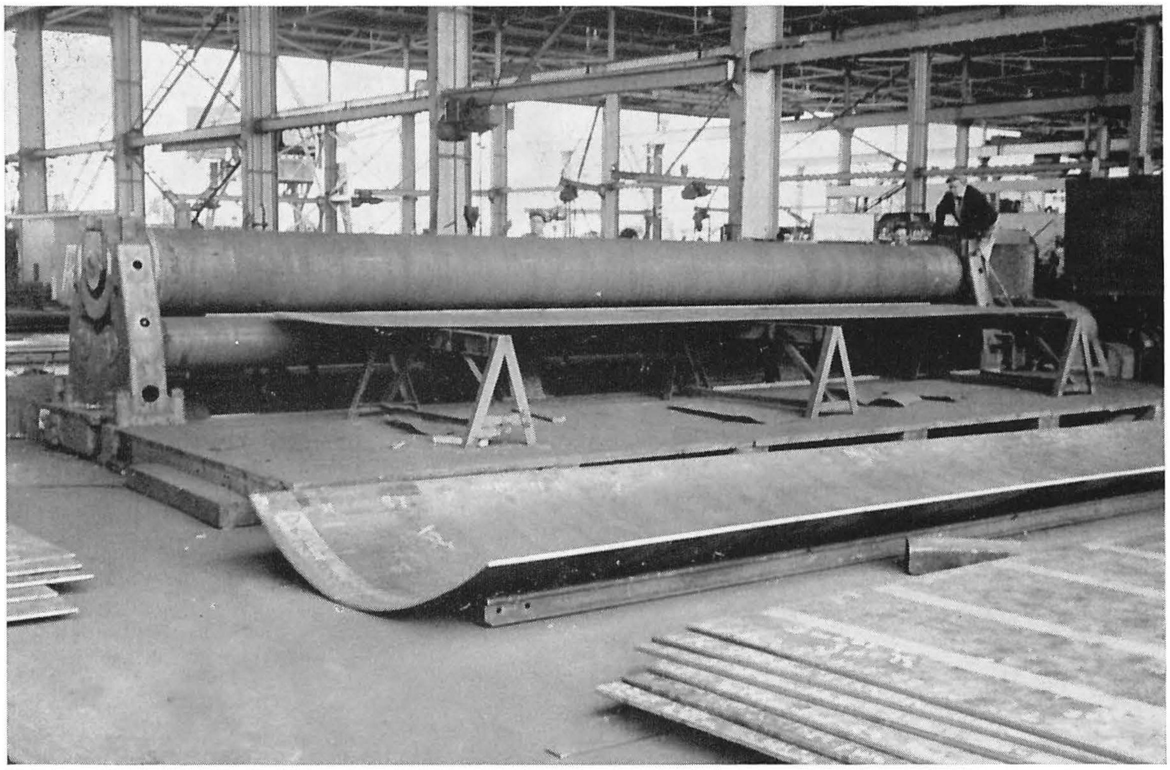
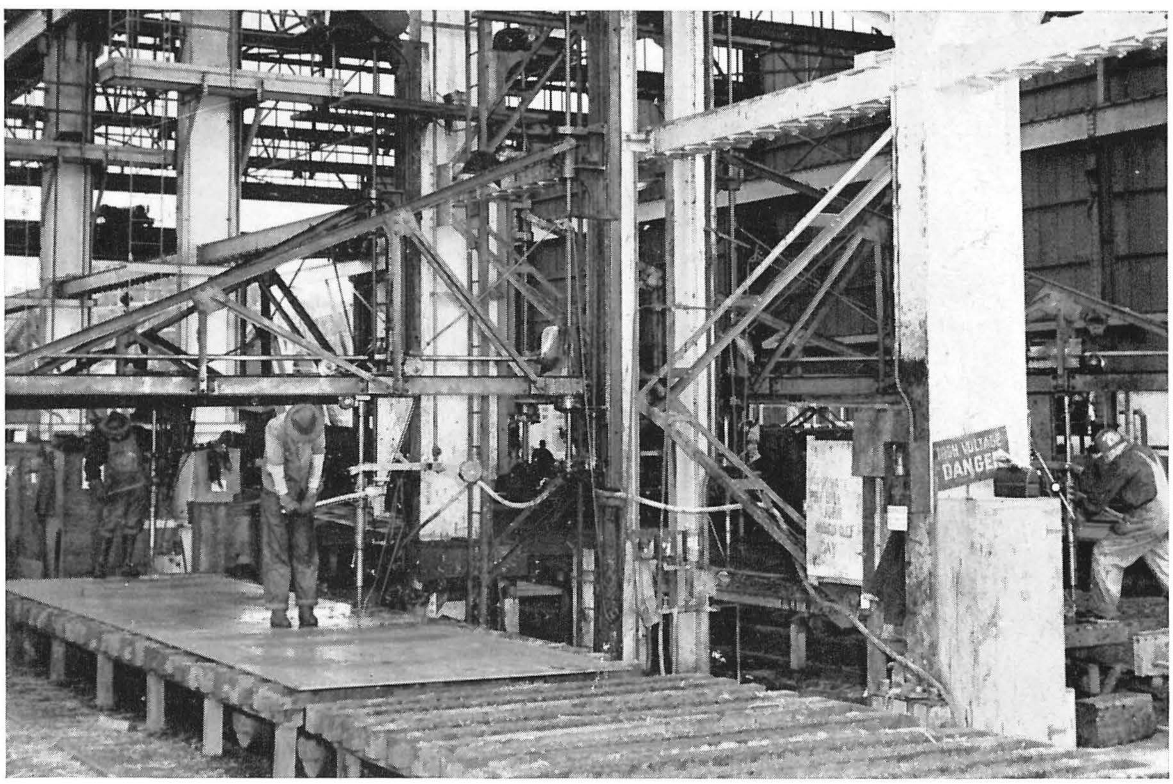
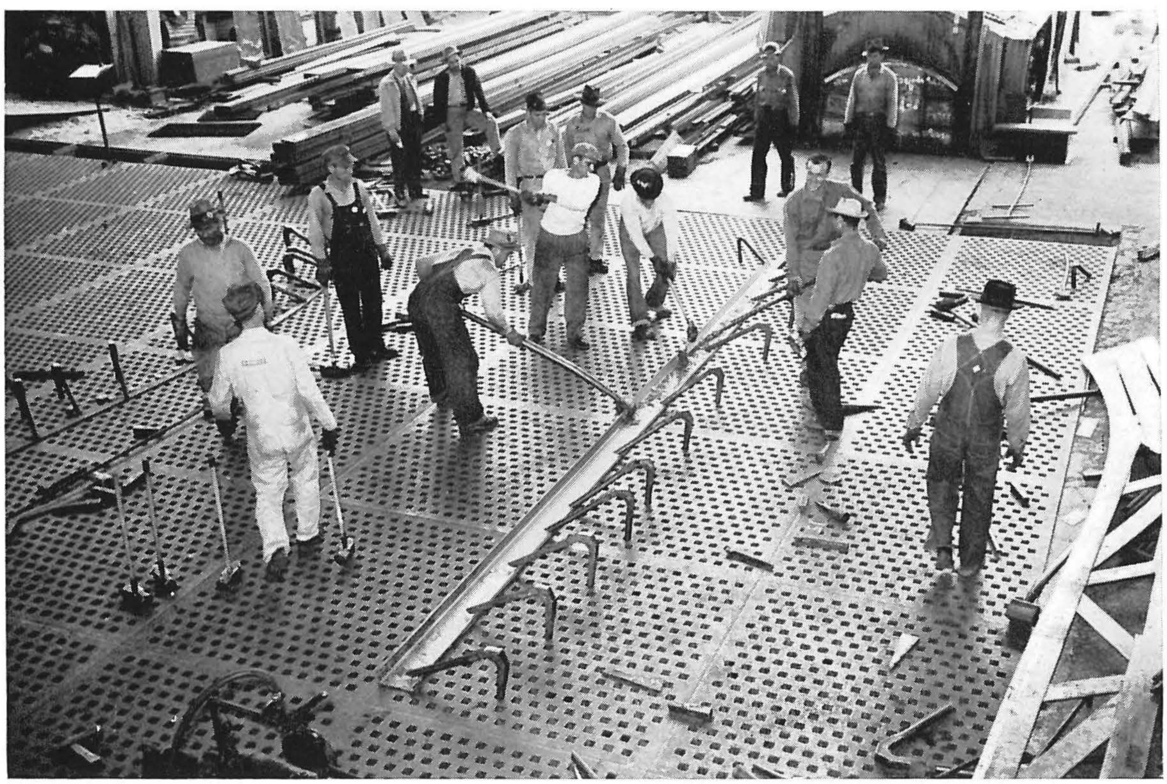


Plate Roll



Four Radial Drills. Plate Carriage on Tracks.

Pulling Frame From Furnace.



Bevelling Frame.

storage yard, thereby relieving considerably the already well loaded cranes that feed the shop and handle the steel in the shop.

Planograph Cutting Small Parts.

Shop Equipment

The equipment provided in the shop includes the following major items:

Bay 1—Plate bending and straighteningrolls
400 ton presses
Radial drill

Bay 2—Plate roll
Twin 400 ton press
Radial drills

Bay 4—Plate shear
Plate straightening roll
Punches
Drill presses

Bay 6—Punch and shear

Bay 7—250 ton press
Punch and shear

Bay 8—250 ton press
Punch
Shape furnaces and bending slabs

Bay 9—Shape furnaces and bending slabs

Bay 10—Drill presses
Shears
Punches
Plate rolls
Miscellaneous small equipment.

In addition to the above the bays are serviced by 10 ton bridge cranes, jib cranes with electric hoists, and other miscellaneous equipment.

The Flame Cutting Equipment includes

33 Radiagraphs	2 Oxweld CM-16
2 Link Belt Flame Planers	3 Oxygraphs
4 Travographs	1 Planograph

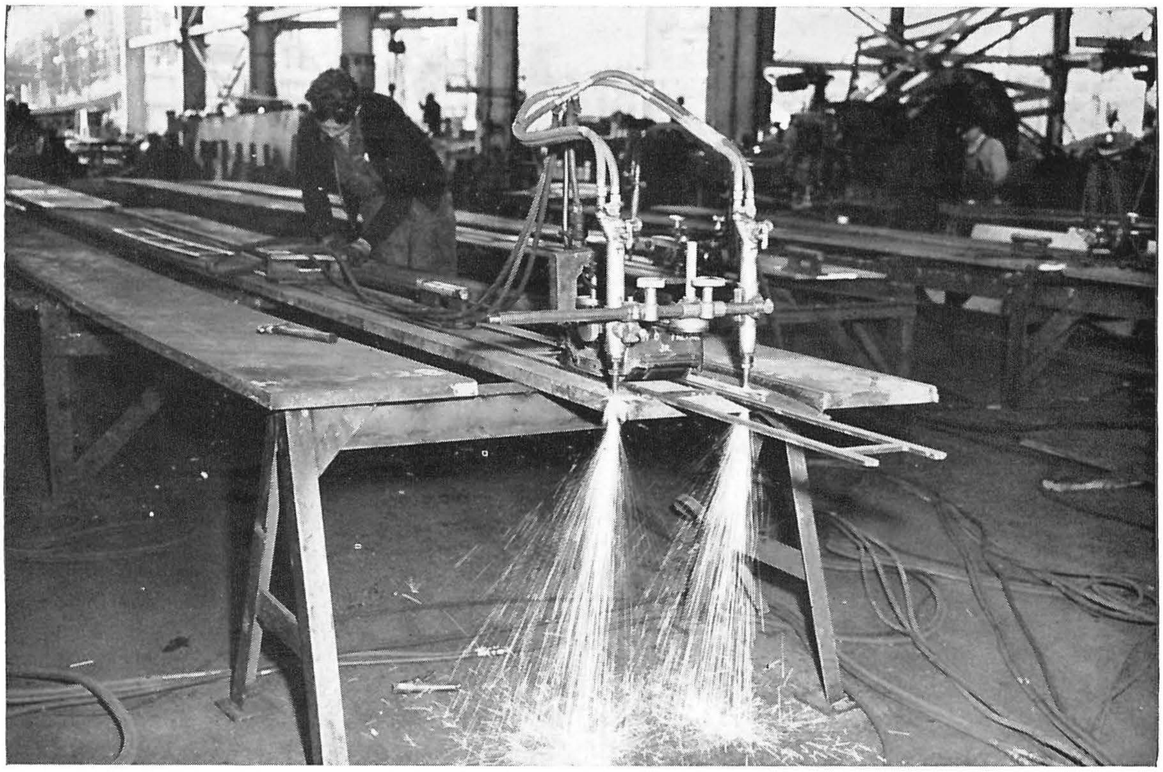
Flame Cutting Equipment

In view of the extensive use of a flame cutting equipment in the fabricating process of the shop, a description of the various units is given below:

Radiagraph—One or two torches are mounted on a small self-propelling carriage that can travel on a track or against a straight edge or template. Parallel burns up to five feet apart can be made; also the torches can be adjusted for any degree of bevel desired.

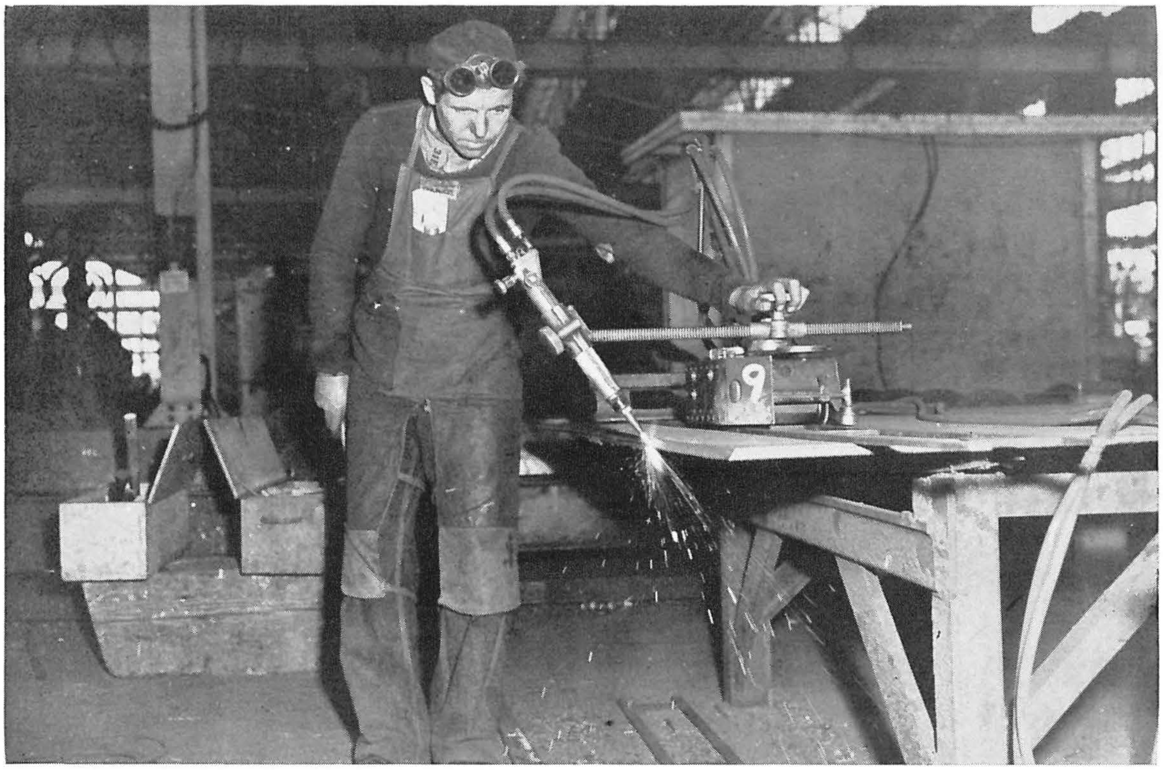
Oxweld CM-16—One torch is mounted on a small carriage that can be guided by hand to follow any line or to scribe a circle around a radius bar.

Manually Operated Oxweld CM-16.

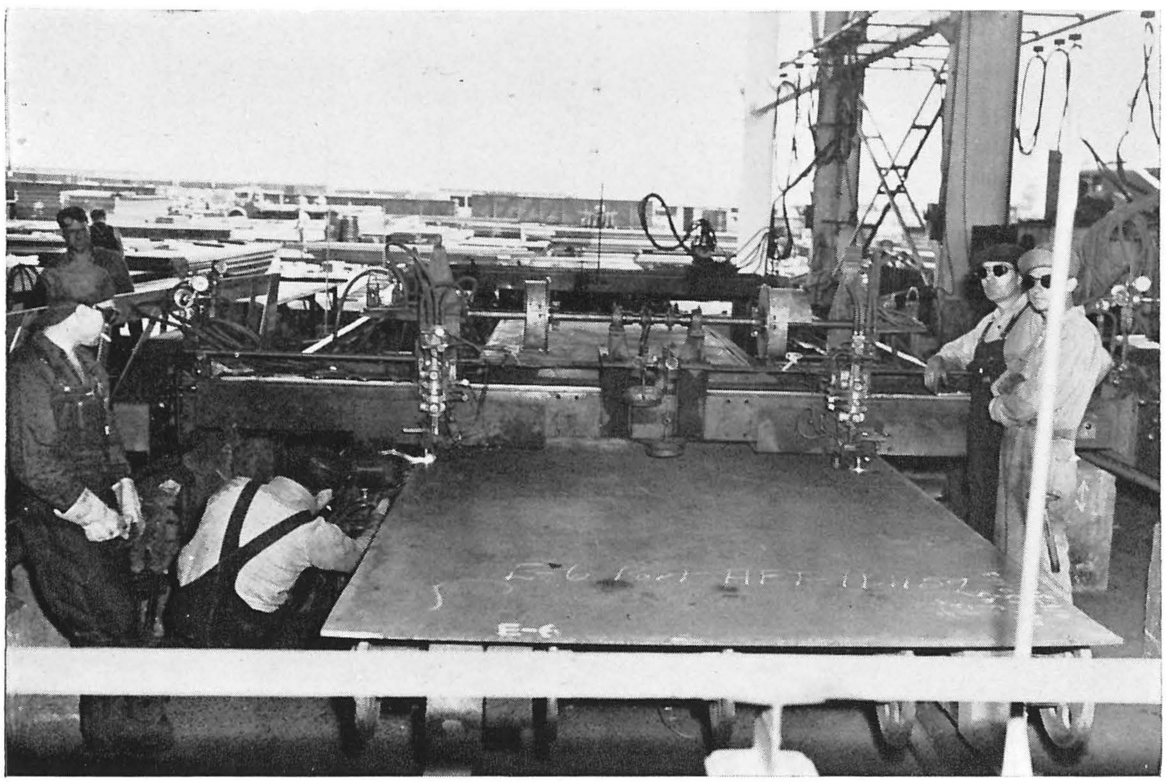


Radiograph

Oxygraph at Right



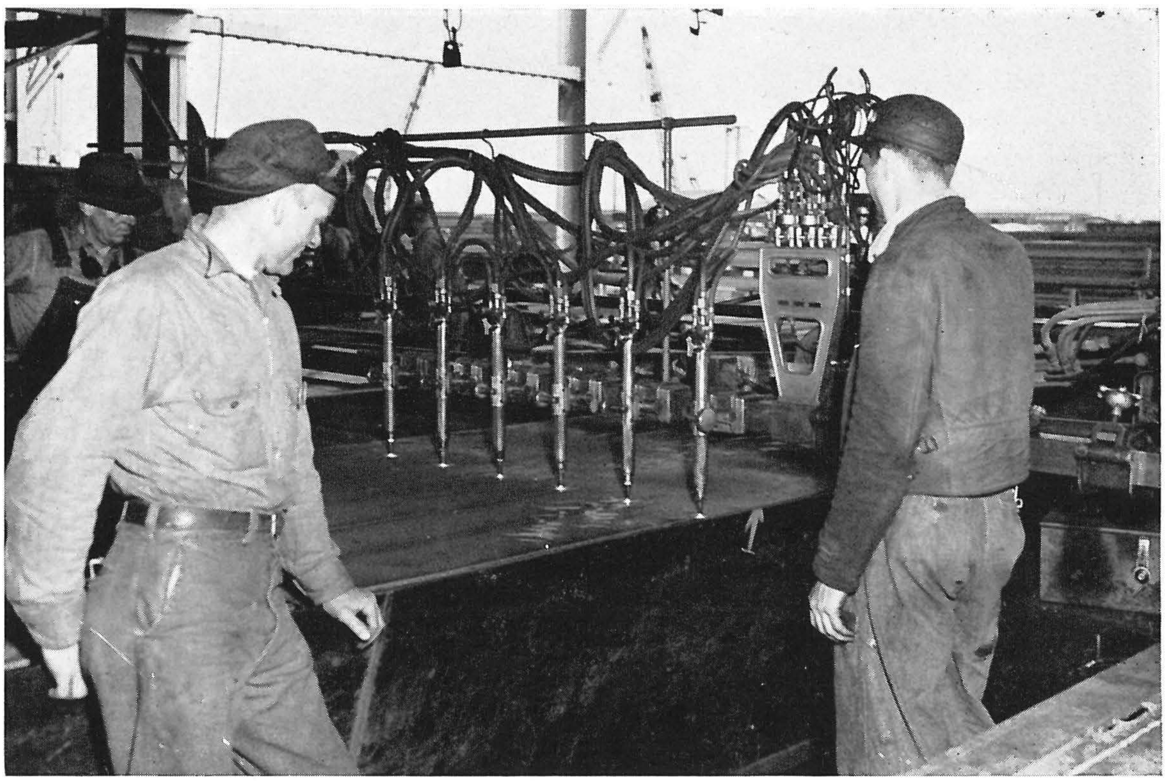
Radiograph Cutting Bevel



Link Belt Flame Planer Cutting Shell Plate

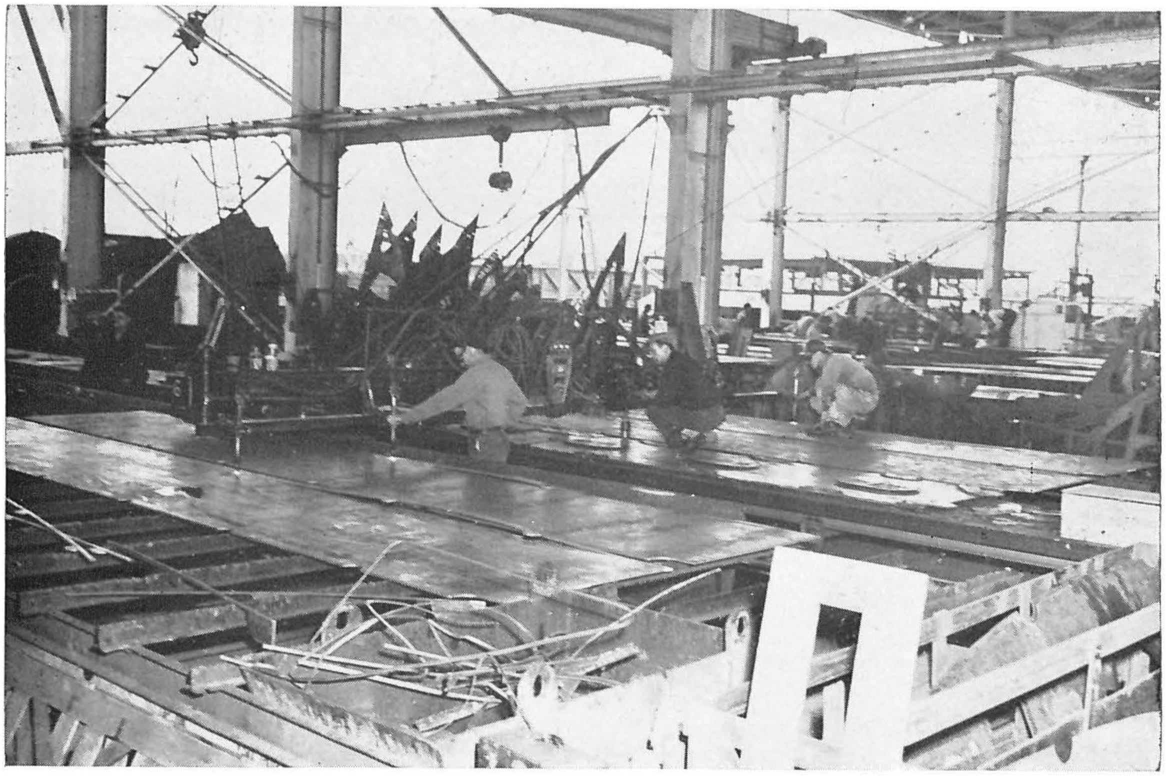
Link Belt Flame Planer—A wide carriage traveling on rails carries a cross bar on which are mounted two torches to make parallel cuts. Cams have been added to each side of one of the planers by the shop to provide non-parallel cuts. Each torch follows a curve or straight line dictated by its cam, independent of the other torch. The rise and fall of the cams is that of the curve of the plate, but the length of the cam is 1/11 that of the plate and the cam travels 1/11 as fast as the carriage. A separate pair of cams is available for each shell plate cut on the Link Belt flame planer. The shape is obtained from the developed plate in the mold loft, laid out with full rise and fall but reduced length on a template, and rolled into shape.

Oxygraphs—A number of torches are mounted on a cross bar supported at each end on jointed arms swung from fixed supports. The bar is free to move parallel to itself lengthwise or sidewise while a magnetic rotor traces around a steel template; also the tracer can be made to follow any template by manual control. A movable table is to be installed to provide a wider range of work.



Travograph

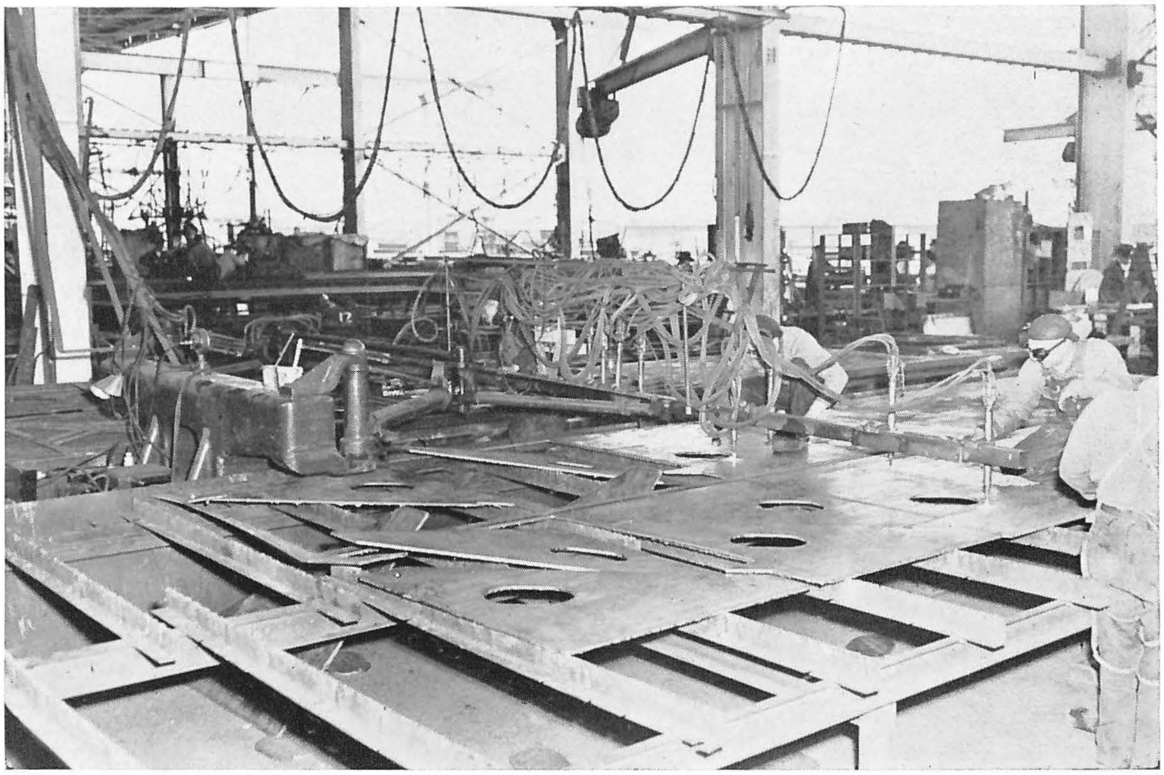
Travograph—The cross bar and jointed arms of an oxygraph are swung from a self-propelled carriage. Four to eight torches on the arm make parallel cuts as they follow the magnetic tracer traveling along a steel template, or as with the oxygraph the tracer may be used to follow a template with manual control. The carriage speed is set as desired, and the movement of the carriage is controlled by automatic switches.



Travograph Cutting Lightening Holes From Metal Cam

Oxygraph

Planograph—A small cross arm holding two torches is swung like a travograph from a small carriage that moves back and forth on another carriage which in turn moves on a longitudinal track. This latter carriage was added in the shop to cover a wider range of material without shifting. The planograph is used principally for small flame cut parts such as the flanges and rigging details fabricated in bay 10.



Travograph Cutting Margin Brackets

FABRICATION BY FLAME CUTTING EQUIPMENT

The items that are fabricated by flame cutting in each of the bays are

Bay 1

- Flat Keel Plates
- Shell Plates
- Hatch Brow Plates
- Mast House Plates
- Bulwark Plates
- Plastic Armor Plates
- Shaft Tunnel Plates (part)

These plates are all cut with radiagraph burners using tracks or templates.

Bay 2

- Shell Plates

The shell plates for the side shell erection sections and the mid-section flat bottom plates are cut on the Link Belt flame planer using cams where other than parallel burns are required. The balance of the plates are cut with the radiagraph burner using wooden burning templates. The templates are 28″ narrower than the corresponding layout template, permitting a radiagraph to operate on each side simultaneously. The ends of the plates are cut with radiagraphs on tracks.

Bay 3

Tank Top Plates
Second Deck Plates
Upper Deck Plates
After Deck House Plates
Vertical Keel Plates
Transverse Bulkhead Plates
Steady Bearing Foundations
Shaft Tunnel Plates (part)

The Link Belt flame planer handles all burning of plates over 25′ long. The majority of the plates are cut with the radiagraphs working against the steel straight edge. The balance of the plates are cut by radiagraphs using standard track. This type of cutting is satisfactory where unionmelt welding is not required.

Bay 4

Tank Top Gussets

These are multiple cut by a travograph operating against a long wooden template. 2″, 4″, and 9″ gussets are cut from two plates at a time, using 4 torches on each plate.

Margin Brackets

A travograph equipped with a magnetic tracer operating against a steel template cuts these brackets. The steel template is worthwhile because there are many identical pieces of marginal brackets to be fabricated.

Bulwark Brackets

The outline of the bracket is traced on the plate from a mold loft template. Then this line is followed by the travograph with a manual tracer. All of these brackets are different, so it is not economical to set up a template for each one.

Afterpeak and Forebeak Plates,

These plates are hand traced by a single torch on an oxweld CM-16.

Boiler Foundations

Drain Hats

Miscellaneous Shapes

These are cut by radiagraph with standard track.

Bay 5

Midship Deck House Plates
Bridge Deck House Plates
Boat Deck House Plates
Machinery Casing Plates
Center Line Bulkhead Plates
Miscellaneous Bulkhead Plates
Machinery Flat Plates
After Deep Tank Plates
Second Deck Girders
Upper Deck Girders (part)
Escape Trunks
Fuel Oil Settling Tanks

The plates that will be unionmelt welded are cut by a travograph or with a radiagraph and steel template; the balance is cut by a radiagraph on standard track.

Bay 6

Solid Floors (50%)

The travograph cuts four at a time, two on each side of the machine, using a master jig with templates for the bilge end of all floors.

Intercostal Longitudinals

An oxygraph makes multiple cuts using a magnetic tracer on steel template.

Hatch End Beams and Longitudinal Deck Girders

A radiagraph on standard track using parallel torches cuts the plates. The channel stiffeners for the upper deck hatch end beams and hatch side girders are trimmed to required depth and flange width by a radiagraph equipped with rollers that follow the heel of the channel.

Bay 7

Solid Floors (50%)

The floors, including those requiring stiffeners, are cut 4 at a time by a travograph using a master jig and a template for the bilge end of the floor.

Gun Platform Plates

These relatively small plates are cut by a radiagraph on a standard track.

Bay 8 and 9

Forepeak and Afterpeak Frames

The frames are cut from bulb angles by radiagraphs equipped with following rollers.

Bay 10

Miscellaneous Small Parts

There are a large number of duplicate small parts that can be cut from a plate in multiple cuts by a planograph.

Hatch Covers

Ventilating System Plates

Sea Chests

Since these shapes are of varying size, they are individually cut by a radiagraph on a track.

Shop Pre-Assemblies

In order to speed the work of the sub-assembly skids and of the hull, the shop assembles some of the plates and shapes that it has fabricated. The principal items pre-assembled are hatch end beams, and longitudinal deck girders, boiler foundations, deep tank covers, shaft tunnels, parts of the flying bridge, foundations, and pedestals. Also the frame brackets are welded to the side shell frames and the 'tween deck frames.

Some of the principal shop pre-assemblies are described below.

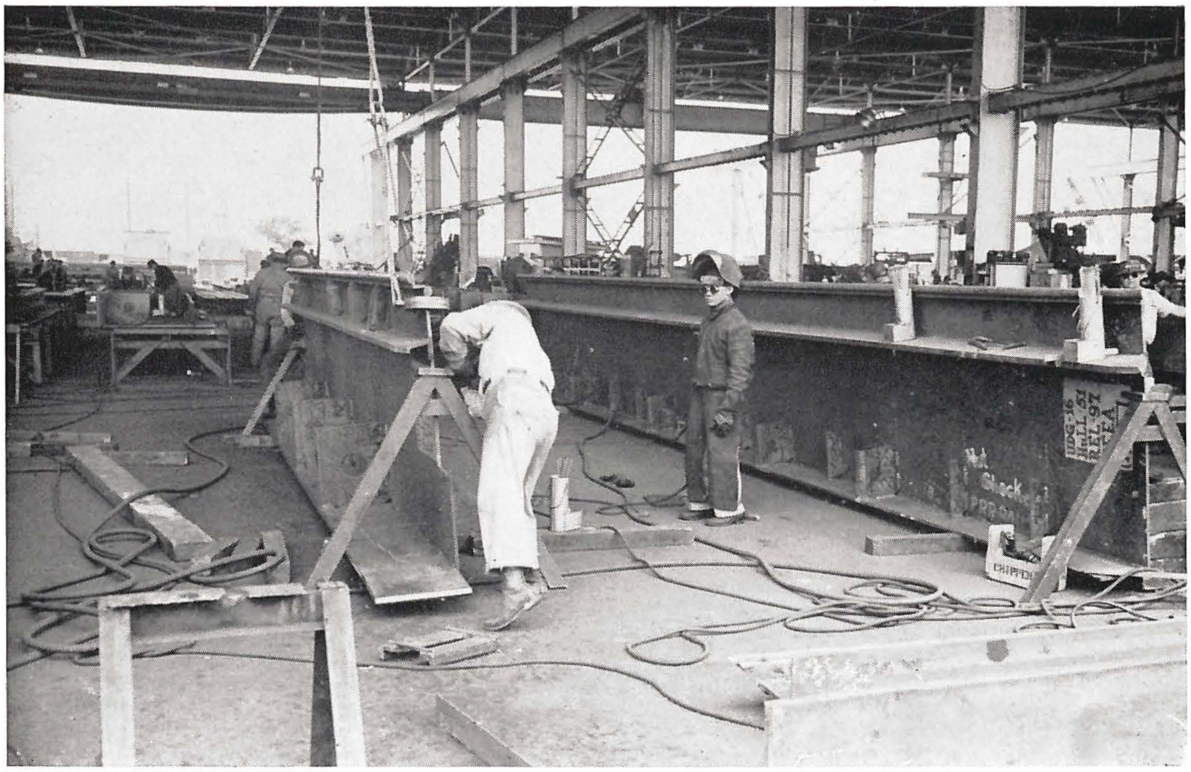
Upper Deck Hatch Beams

The hatch beams of the upper deck sub-assemblies are assembled at the shop. The longitudinal hatch side girders are made in one piece. The transverse beams would be quite long to handle and store in one piece so they are fabricated in three sections, the center section at the hatch and the two outboard sections.

The girder is assembled on horses and then bolted into position for welding. First the web is set on the horses, and then the face plate is set upright on the web and tacked in place. A diagonal brace from the web to the top of the face plate on each end holds it in position. The bracket plates are tacked to the web and to the face plate. The stiffeners and the coaming angle are set and tacked, and spacer bars are dropped between the stiffener and the angle to keep them from warping.

The welding of the face plate, stiffeners, and coaming angle is part solid and part intermittent. In each case, the procedure is similar. The bead is marked out in 1, 2, 3, 4, series starting at the center and repeating out to the end each way. First all of the 1's are welded from the center out, then the 2's, then the 3's, and last the 4's.

Since the weld can be positioned for the best possible angle, a heavy single pass is made with 5/16" rod. In the case of the solid bead each division of the series of four is about 12" long, which is the length of the bead obtained by one 18" rod in a single pass. The half round is welded to the top of the coaming in the same manner.



Upper Deck Girders

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SECOND DECK HATCH BEAMS

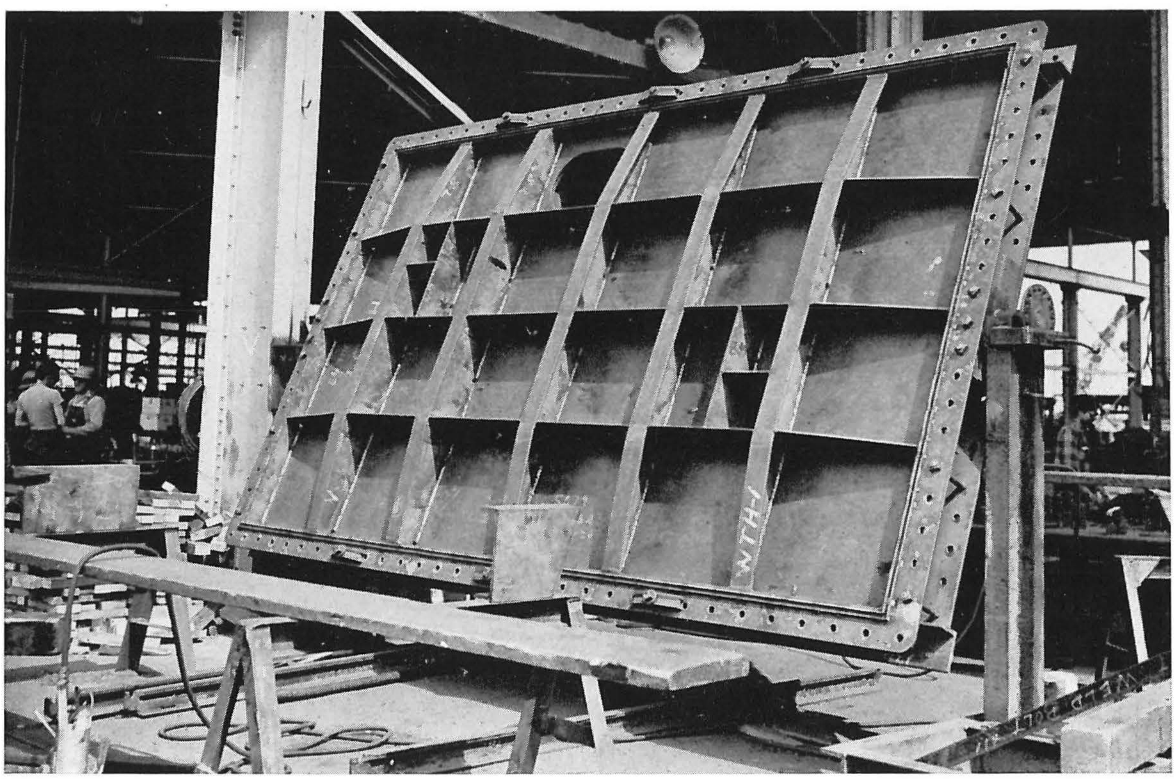
The second deck procedure is similar to that of the upper deck. At the present time the beams or girders are not put in a positioner, but they will be in the near future.

•

BOILER FOUNDATIONS

The boiler foundation beams are assembled and tacked in a heavy jig with clamps and wedges to hold the web and flange in exact position. Two beams are then tightly clamped together, flange to flange, and set in the position most convenient for welding.

The welding sequence is similar to that of the upper deck hatch end beams. Starting at the center, the bead is marked off in a series of 4, and the 1's, 2's, 3's, and 4's are welded from the center out.



Forward Deep Tank Covers in Positioner for Welding

SUB-ASSEMBLY

In order to speed the construction of the hull, most of the steel plates and shapes are sub-assembled on the skids into large units weighing as much as 52 tons; and in turn to speed up the sub-assemblies, some of the small units that go to make up the sub-assemblies are pre-assembled in the shop.

There are a number of advantages to be gained by sub-assembling the major part of the hull. The most important gain is speed, for because of sub-assembly the welding is 54% complete, and over 30% of the labor has been done on the hull before it reaches the ways.

The next advantage is the efficiency to be obtained by assembling the plates and shapes on the level skids where they are readily accessible. Decks and tanks can be turned over so that the welding is downhand. On the hull, the parts are fixed and relatively inaccessible. The third advantage is the saving in crane time when in one load a side shell section is erected that would require 31 trips if the pieces were handled separately.

The size of the sub-assemblies is determined by the capacity of the cranes. The greatest weight that has been sub-assembled so far in this yard is the forepeak weighing 52 tons.

The heavy bulky assemblies are built on the skids directly in front of each building way. The double bottom sections, upper deck sections, flat bottoms, side shell, and bulkheads 68 and 88 for a particular hull are thus built on the skid in front of the way on which that hull is being built.

There are, in addition, other assembly skids on which are assembled certain sections for all hulls. A skid west of the ways and one south of skids 1 and 2 are used to assemble the superstructure bulkheads, decks, and mast houses. The forepeak is assembled at a skid just north of the east corner of the shop. Bulkheads, tanks, and machinery casings are assembled at the east assembly skid south of skids 10 to 14. Fan tails, 'tween deck bulkheads, and second decks are assembled on a skid east of the ways.

The yard design was adequate to suit the original program of ship construction scheduled. With the advent of the war and the demands for greater production and faster schedules, transportation has grown to be a tremendous problem, particularly through the area between the shop and the skids. All of the flow of material from the shop and to the skids passes through that area, and at times the sub-assembly skids have been delayed by lack of adequate transportation.

To remedy this situation, construction has been started on a large sub-assembly building at the east end of the yard which will provide the additional area required and permit moving some of the skids to provide room for a larger truck way north of the shop. As part of this same program, the length of the skid west of the ways has been increased to provide additional superstructure assembly area.

The drawings on the following pages show the principal parts of the hull. These principal parts have been divided for sub-assembly as follows:

Flat Bottom—The A, B, and C strakes on each side of the flat keel in the midship region have been divided into five sections port and starboard. These flat bottom sections are sub-assembled on skids and have only to be welded to the flat keel and to each other. The curved plates fore and aft are individually set in place. These and the flat keel are practically the only parts of the hull that are not sub-assembled, at least in part. The flat keel is laid on the keel blocks in individual sections which are as long as can be handled without bracing.

Double Bottom—The tank top, vertical keel, floors, and intercoastals are assembled into eleven large units on the way skids. These units are referred to in the description as "double bottoms" since they with the flat bottom comprise the double bottom portion of the hull.

Bulkheads—All of the bulkheads, large and small, are assembled on the skids where the plates can be welded by machine and where the manual welding is practically all on flat surfaces.

Side Shell—The side shell, except for some of the end plates with double curvature, has been divided into six erection sections port and starboard which are assembled on the skids and set into place by the crane. These sections are difficult to store at the skid, and therefore the skid schedule must dovetail with the hull schedule.

Decks—Both the second and upper decks are assembled in convenient sections complete with deck plate, beams and girders.

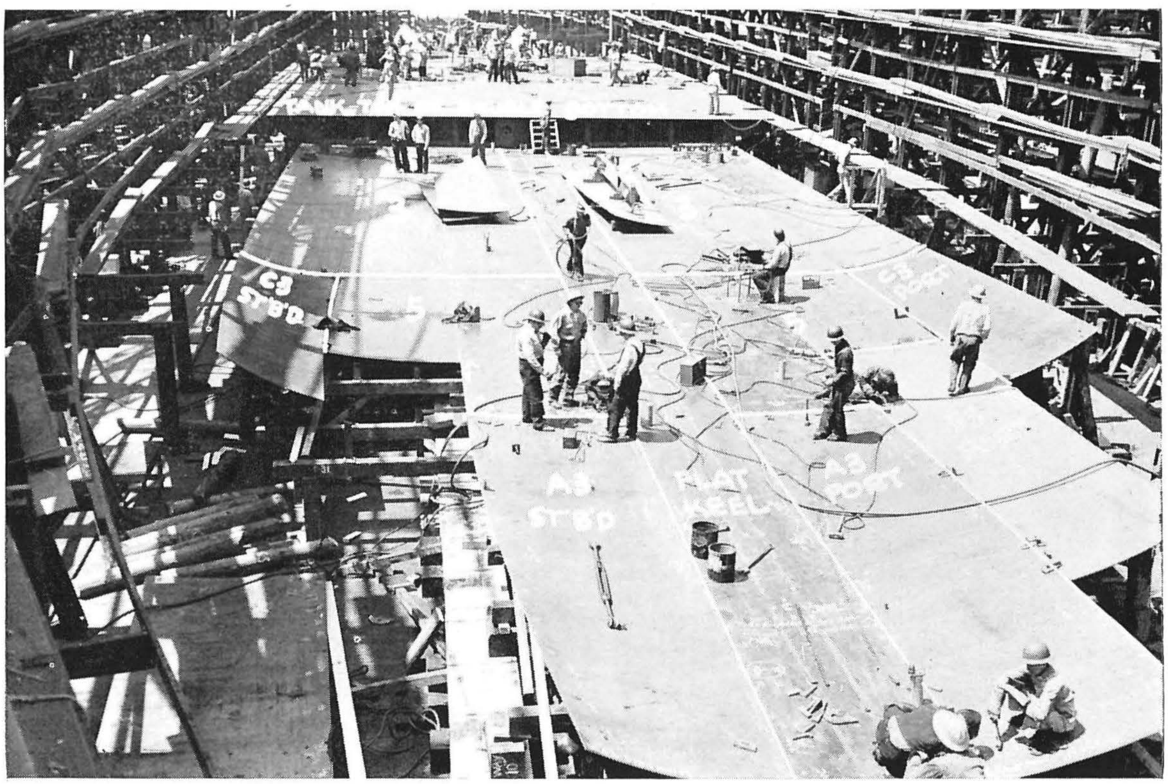
Superstructure—The bulkheads are assembled on the skids and individually erected on the hull. The superstructure decks are assembled in large sections and set over the superstructure bulkheads on the hull. The three mast houses are completely assembled on the skids and set on the hull ready to be fitted to the deck.

Forepeak—This is probably the most difficult sub-assembly that is made at the yard. The forepeak of the hull from the stem bar aft to bulkhead 12 and from the second deck to the keel is assembled in one piece and then erected on the hull.

Fan Tail—The portion of the afterpeak from frame 174 aft is assembled as a unit. It is proposed to assemble the remainder of the afterpeak in several large sections as soon as assembly area is available. These sub-assemblies are described in detail on the pages that follow.

Sub-Assembly of the Flat Bottom

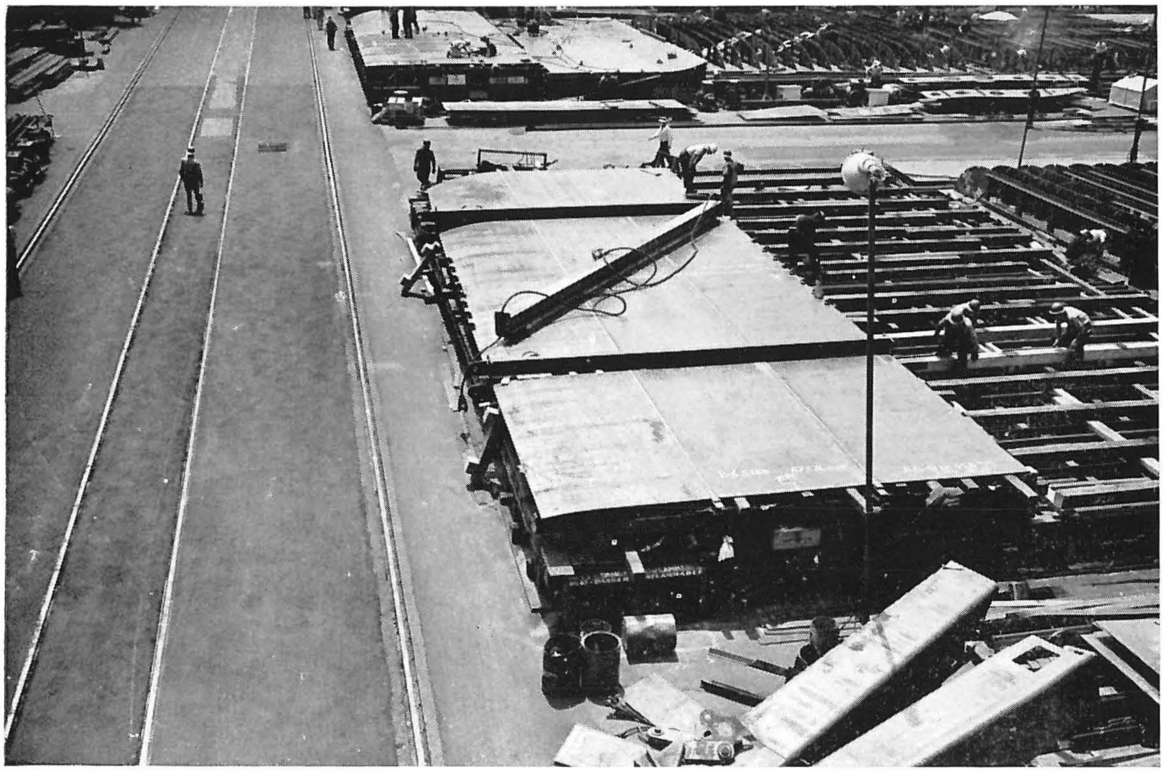
The flat bottom or bottom shell plating of the hull is made up of flat and curved plates. The sub-assemblies of these plates consist of five erection sections on both the port and starboard sides of the flat keel. Erection sections 1, 2, and 3 consist of two plates each of the A, B, and C strakes. The end erection sections 4 and 5 consist of one plate each of the A and B strakes.



Flat Bottom With Center Double Bottom Sections in Place and Individual Shell Plates Forward.

These are the first sub-assemblies to go on the hull, since the flat keel, which is the first part laid, is in the form of individual plates from the shop.

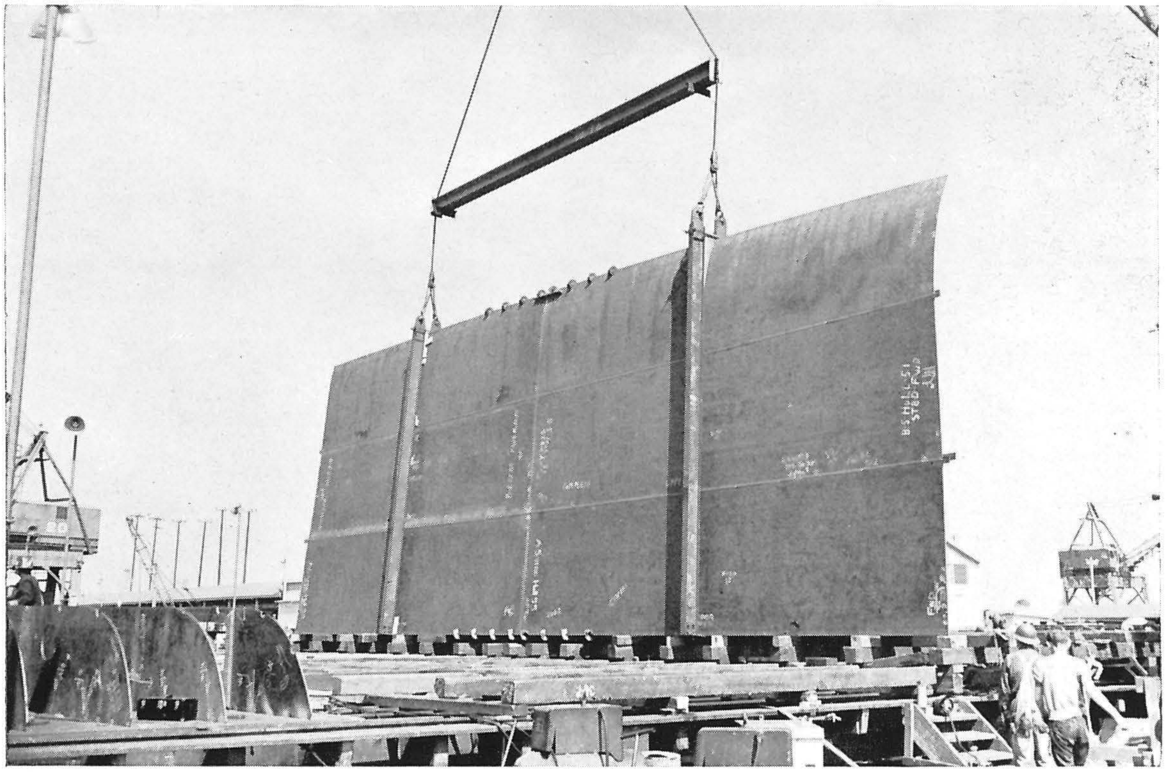
A wooden jig with steel rails at the flat bottom seams is placed on the skids, and the plates of the section are laid on the jig, bottom side up. The same jig serves for all sections with varying heights of blocking under the curved outboard edge, depending on the section.

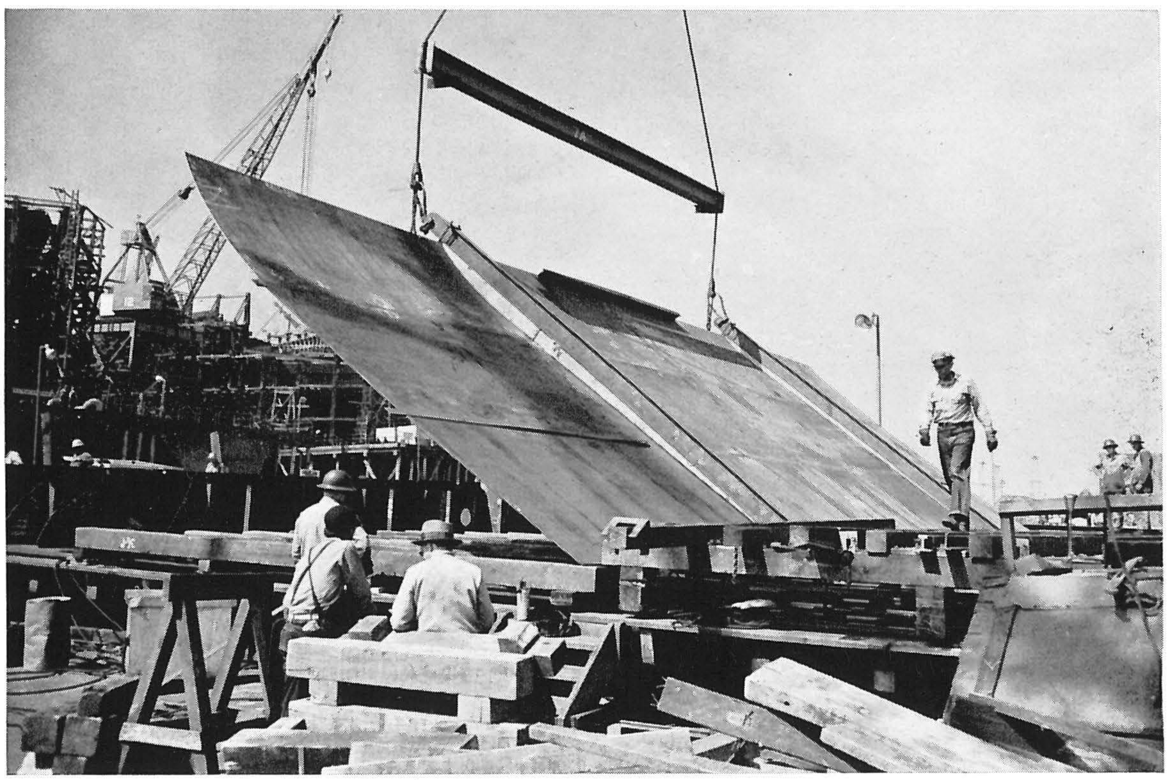


Flat Bottom Section Ready To Be Turned.

Before the plates are laid down, back-up bars are placed on the steel rails under the unionmelt seams. At the start of operations, these bars were 5/8" thick and would last for only two or three sections before the heat of the unionmelt welding warped them excessively. Now a 1/8" bar is used on top of a 1/2" bar, and the thin 1/8" bar will last for the welding of the full five erection sections of a hull since it is easy to straighten and it does not warp greatly from the heat of the unionmelt. The space between the 1/8" and "1/2 bars allows the bars to cool quickly; also the 1/8" bars are more flexible and easier to wedge up to the flat bottom to keep the unionmelt from blowing through. The 1/2" bar does not warp and is used continually. Care is taken to see that there are no gaps between the ends of the 1/8" bars that will permit the unionmelt weld to blow through.

The plates are laid on the flat bars and pulled together with pull clips. The jig has timber supports between and about 1/8" below the tops of the rails to keep the plates from sagging between seams.


Turning Flat Bottom Section.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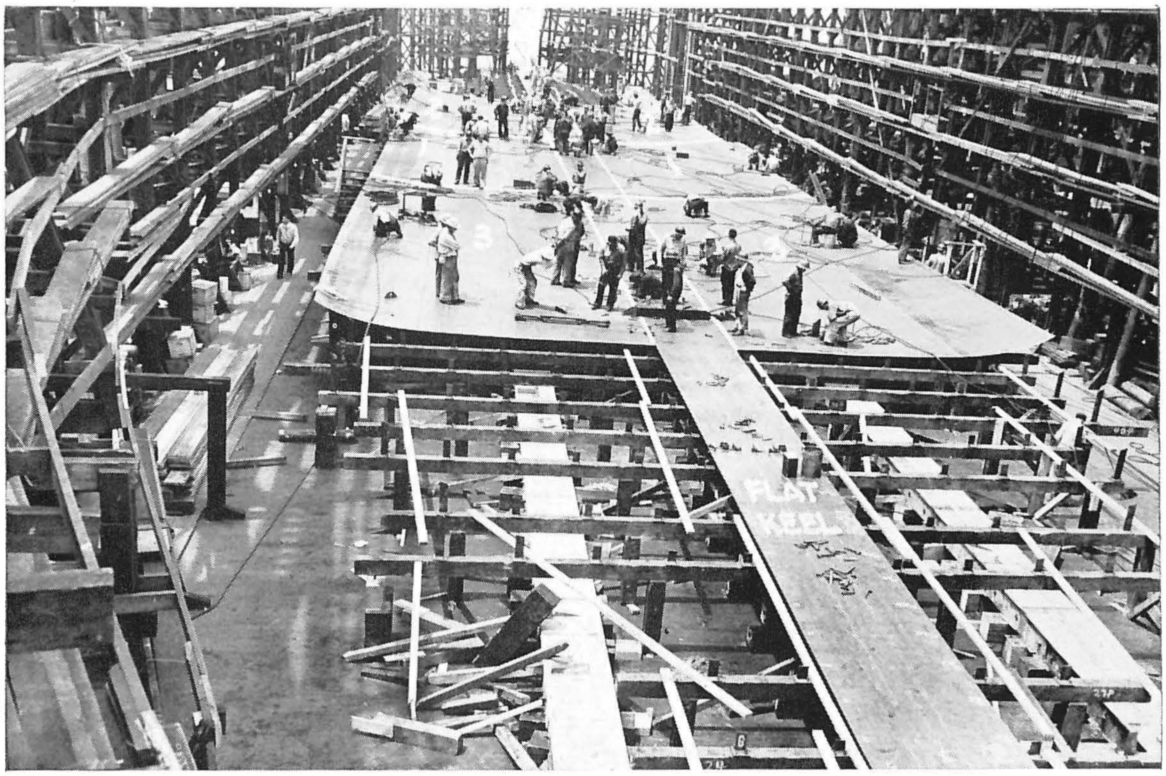


Flat Keel With Flat Bottom Sections 1, 2, and 3, Being Set on Ways.

After the plates are on the jig with the seams fairly well centered on the rails, the A plates are pulled together at the butt and held in place with two bolts and with angle clips which are tacked to the plates. A string is stretched longitudinally along the flat keel seam, and the two A plates are lined up with the string by adjusting the bolts at the butt. The B plates are pulled to the A plates and to each other at the butt. Before the C plates are pulled to the B plates, a short weld is made in the B plate butt to eliminate any movement as the C plates are pulled. Tacking can start as soon as the B plates are in place, but the edge of the A plate is continually checked against the string to see that the plates have not moved.

Before tacking the C to the B plates, the girth measurements are checked and the curve of the C plates is checked by a template. Any adjustment is taken at the B-C seam. The plates have been cut by a template, and there is no excess stock to be trimmed so considerable care should be taken with the joints.

Before the unionmelt weld is made, the plates are pulled down tightly to the rails of the jig. Horseshoe saddles are placed under the rails and tacked to the plates, and wedges are driven between saddle and rail. If the plate will not quite pull down at any place, the back-up bars are wedged up to the plate to keep the unionmelt weld from blowing through.

The edges of the plates are securely dogged down to the jig all the way around. Also, a long strongback is placed across each end of the butt seam to prevent buckling. The C strake end of the butt is left unwelded for 18″ to facilitate fitting it on the hull.

The sequence of welding on the flat bottoms is slightly different from that on some of the other sub-assemblies where the general rule is to start at the center and work out. Several different sequences of welding have been tried, but the present one seems to give the least disturbance. A two foot weld is made at the end of each seam of the section. Then starting two feet from the butt across

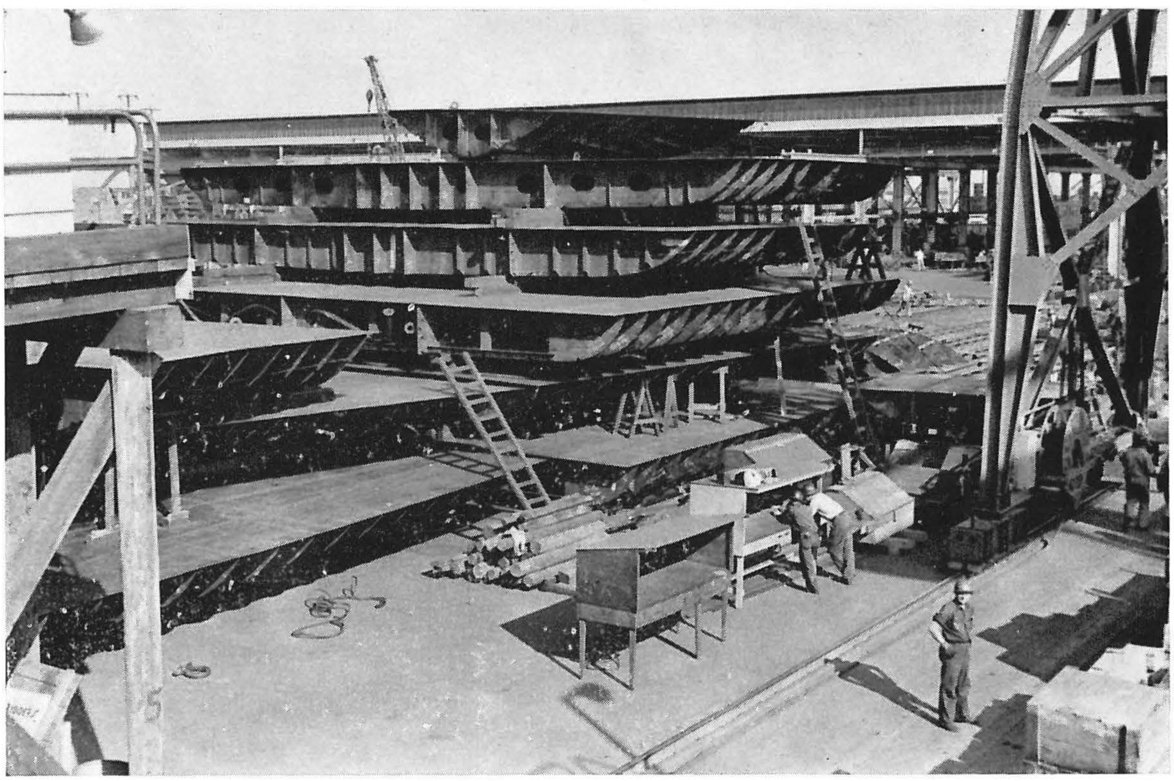
the middle of the section, the weld is made away from the butt to the end weld on both seams. The welding of the seams is completed by working the other way to the end of each seam. The butt is then welded both ways from the center.

After the unionmelt is completed, the saddles are cut loose from the underside, and a crew can start putting on the turning strongbacks. A bar on edge is welded at the C strake end of the butt seam on the underside of the plate before turning, to help stop buckling when the final unionmelt weld is made.

The flat bottom does not have any beams that will stiffen it while it is turned; therefore two steel lifting strongbacks are clamped around each section at the quarter point. Special wooden pieces fill the space between the curve of the shell and the strongback. The crane hooks onto one end of each strongback and turns the section over. Erection sections 4 and 5 do not have a full set of plates, so 8x8 timbers are clamped around the center of the A and B strakes. The crane hooks onto lugs welded to the plate.

Sub-Assembly of Double Bottom Sections

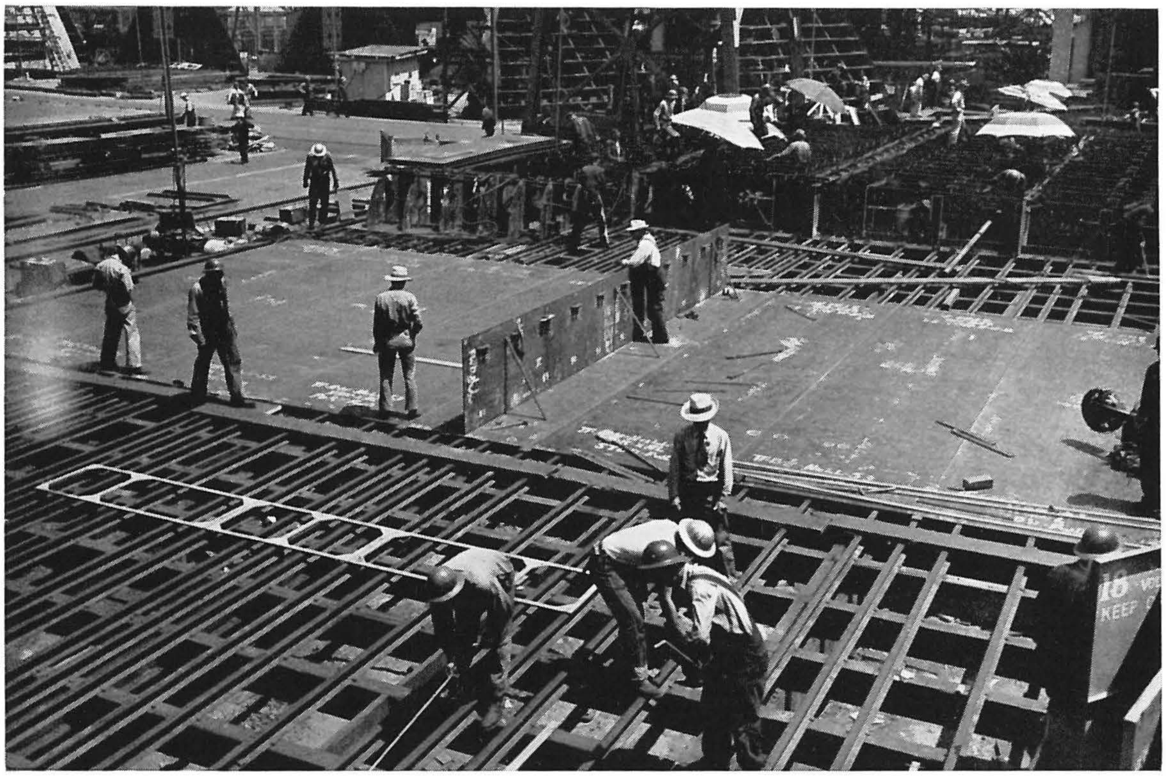
The tank top, vertical keel, floors, and intercostals are assembled upside down in sections on the skids. When erected on the flat bottom, they complete the double bottom of the hull and tanks. The sequence of erection and location of the various sections is shown in the sketch on the following page, and the method of assembling on the skids is described below:



Completed Double Bottom Sections.

The sections vary in length and in size, some having two lengths of shop pre-assembled vertical keel and some only one, but the assembly is practically the same with the exception of sections XAM-XAN under the main engine where the heavy engine bed plate replaces part of the tank top and a special welding sequence is required to prevent warping of the vertical keel. The XAM-XAN procedure will be described last.

The one or two lengths of vertical keel and rider plate are set on the skids on approximate line. All the tank top plates are laid upside down in approximate position; the lettering is on the bottom so that it can be read in an upside down position. The vertical keel is set for alignment and for the



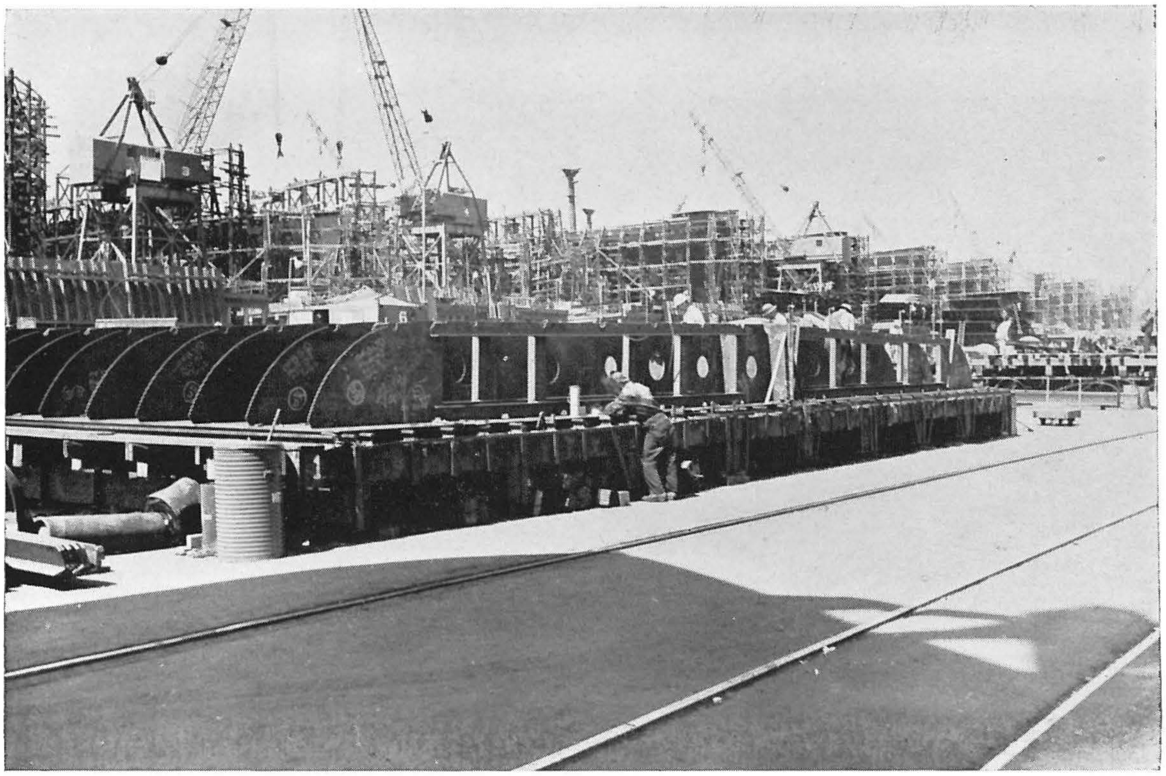
Tank Top and Vertical Keel in Place Ready for Floors.

spacing between floors at the butt of two vertical keel plates, and both the keel and rider plates are tacked at the butt. Then the tank top plates are pulled into place and tacked. The longitudinal seams are joined, and any squaring is done at the butts. As the plates are pulled into place, they are tacked. It used to be the practice to pre-assemble the tank top plates on each side of the rider plate at a unionmelt pre-assembly skid and then transport them in long floppy sections to the skids. It has since been found more practical to assemble the plates on the way skids and unionmelt weld them in place.

An allowance is made in the shop layout of the vertical keel of 1/32″ per frame space for welding shrinkage on the skids. An additional half inch of added stock is also left on the end away from midship of all sections to compensate for welding during erection in the hull. When the layout of the tank top is made on the skid, a welding shrinkage allowance is made fore and aft. 1/32″ is added to the molded distance of the last 6 frames fore and aft on the 40 foot section and to the last 4 frames fore and aft on the shorter sections. In this way the molded lines on the tank are maintained at the proper spacing and at 90° to the keel.

After the plates are tacked, the rider plate butts and the tank top butts are welded out from the keel. Then the seams, starting at the rider plate which is the center tank top plate, are welded both ways from the center by unionmelt. The rails of the skids have been spaced so that there is a rail under each unionmelt seam (except the oblique seams) to prevent their sagging after welding.

As soon as the unionmelt welding is completed, the layout men locate the floor, girders, drain wells, and buttock lines on the tank top. Fitters then set and plumb the floor plates, checking the buttock lines on the floor against the layout buttock lines to see that they are within ⅛″ of each other.



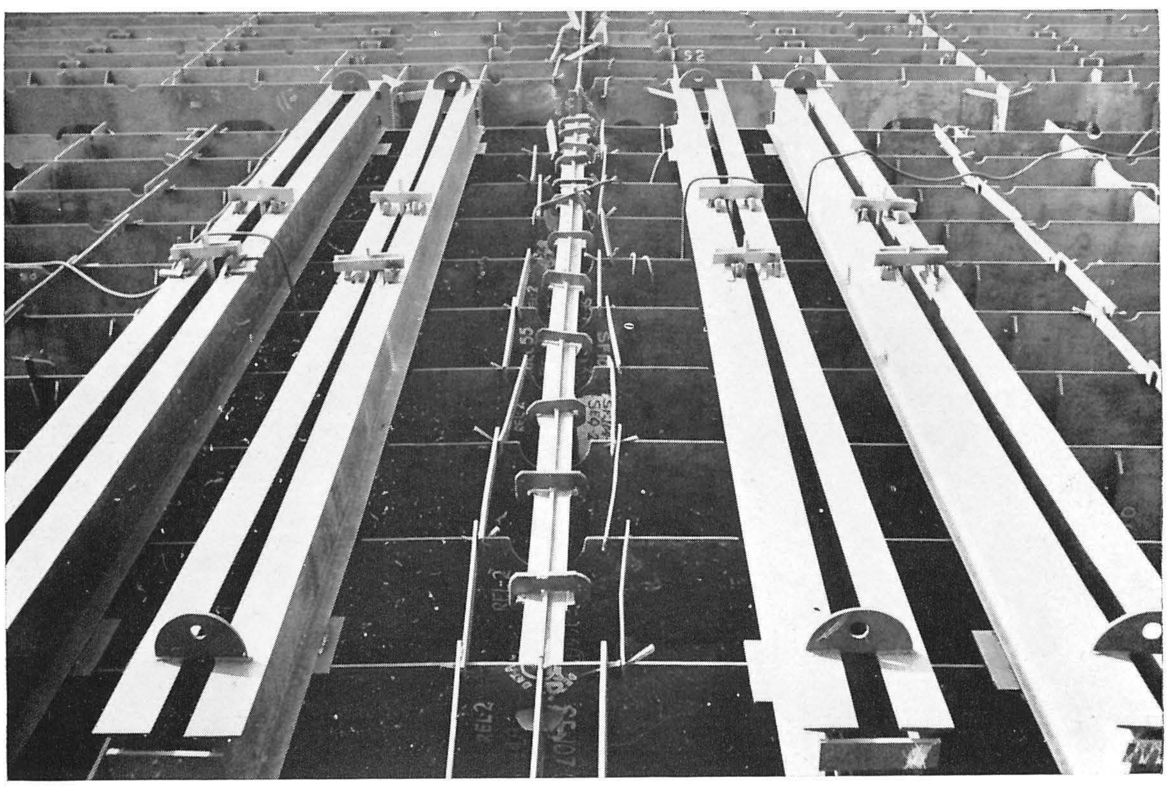
Double Bottom Section Before Turning.

On the engine bed section XAM-N and on the shorter fore and aft sections XAB, XAU, XAC, and XAA where there is a greater tendency for the keel to buckle, a strongback is used composed of bars on edge, wedged tightly against the top of the keel on each side after the floors are in place. The vertical keel is checked to see that it is square with the rider plate before the floors are tacked. Tacking starts at the center of the keel, working both ways to prevent throwing the keel out of line. The floors are tacked both to the vertical keel and to the tank top. A saddle slipped over the floor is tacked to the tank top and is used for wedging the tank top and floor tightly together as they are tacked. After four floors have been set, the welder can start welding the floors to the vertical keel and to the tank top out to the edge of the rider plate. The floors are plumbed as they are fitted and the intercostals set and tacked.

If the remainder of the section is welded without any further precaution, there is a tendency for the floors to pull across the breadth of the ship, causing the tank top to bow up at the sides when the dogs are released. To compensate for part of this curl, it is the practice to lift the section after the floors are welded to the keel and tacked to the tank top, and to place a 3/8" flat under the keel and a 1/4" flat under the rider plate seam. Then the tank top is dogged down tight all around. A section was made recently without the shims, but there was distortion, and it seems advisable to continue their use on all except the very small sections and the engine bed section. A single 1/4" shim is used under the keel of XAC. A 1/4" bar is used under the vertical keel of XAA, not to prevent distortion but to make up the difference in thickness between the rider plate and the tank top plate.

The flat weld along the floor shrinks the tank top and causes the unsupported tank top plate between floors to bow up. To overcome this distortion, stiffener bars are set between limber holes of the floor plates, and wedges are driven between the stiffeners and the tank top to hold the tank top plate tightly against the skids.

Side View Showing Floors, Stiffeners on Tank Top Plate, and Bracing Between Floors.



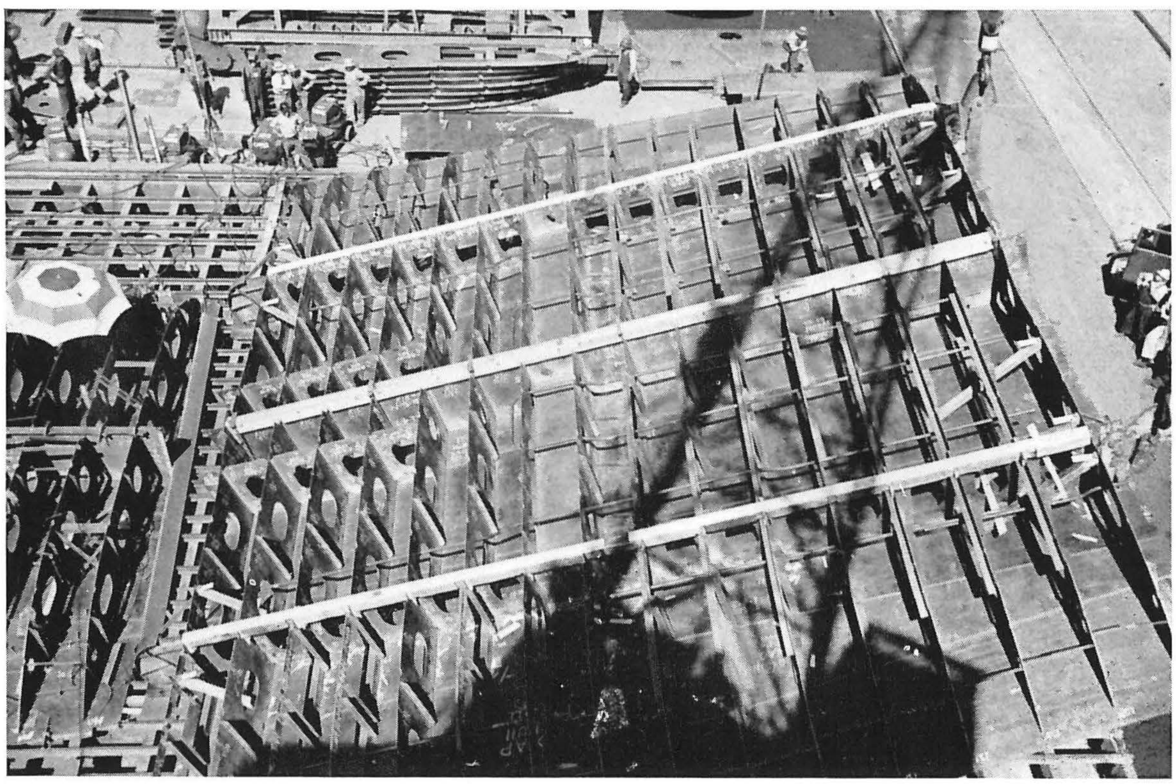
Double Girders Over XAM-N Section: Also Strongback on Vertical Keel.

It is quite important to keep the floors vertical and in place; otherwise, there is considerable labor in fitting them to the bottom shell. At the outer edges, and wherever else the floors might move during welding, braces are placed between floors and diagonally to the tank top. After the section has been braced, the floors are welded from the rider plate out to the end. The intercostals are welded first to the floors and then to the tank top, and the vertical keel is welded to the rider plate.

The engine bed section XAM-N is different from the others because of the different action of the heavy engine bed plate, and in this section the vertical keel is left free longitudinally both ways from a 12″ weld in the middle until all the floors and intercostals are completely welded. The vertical keel is in one piece, but the tank top is assembled from a number of plates. A grill of flat bars has been made that fits on the rails under the thinner tank top plates to bring their upper surface level with the thicker engine bed plate. The vertical keel and the rider plate do not come from the shop assembled in this section. After the plates have been unionmelted, the vertical keel is set to exact location and a 12″ weld is made in the center. The rest of the vertical keel is held down to the rider plate by bolts from temporary angle brackets which will let it move longitudinally.

The layout is made, and the floors and intercostals are set and tacked to the tank top, but not to the vertical keel. This section is not shimmed along the line of the vertical keel and the rider plate, but the strongback along the top of the vertical keel is placed before the welds to the keel progress very far.

After all floors and intercostals are in place, three floors on the port side and three on the starboard are tacked and welded to the vertical keel. Then all the intercostal verticals of these six floors are welded from the vertical keel outward. There is a tendency for this section to curl longitudinally because of the large number of welds near the vertical keel. To overcome this action, four double channel girders are placed longitudinally over the two intercostals on each side of the vertical keel. A ⅝″ plate is placed under the end of the girders sc that the girders are clear of the center of the sec-



Section Being Lifted for Turning. Note Rollers At Left and Lifting Links At Right.

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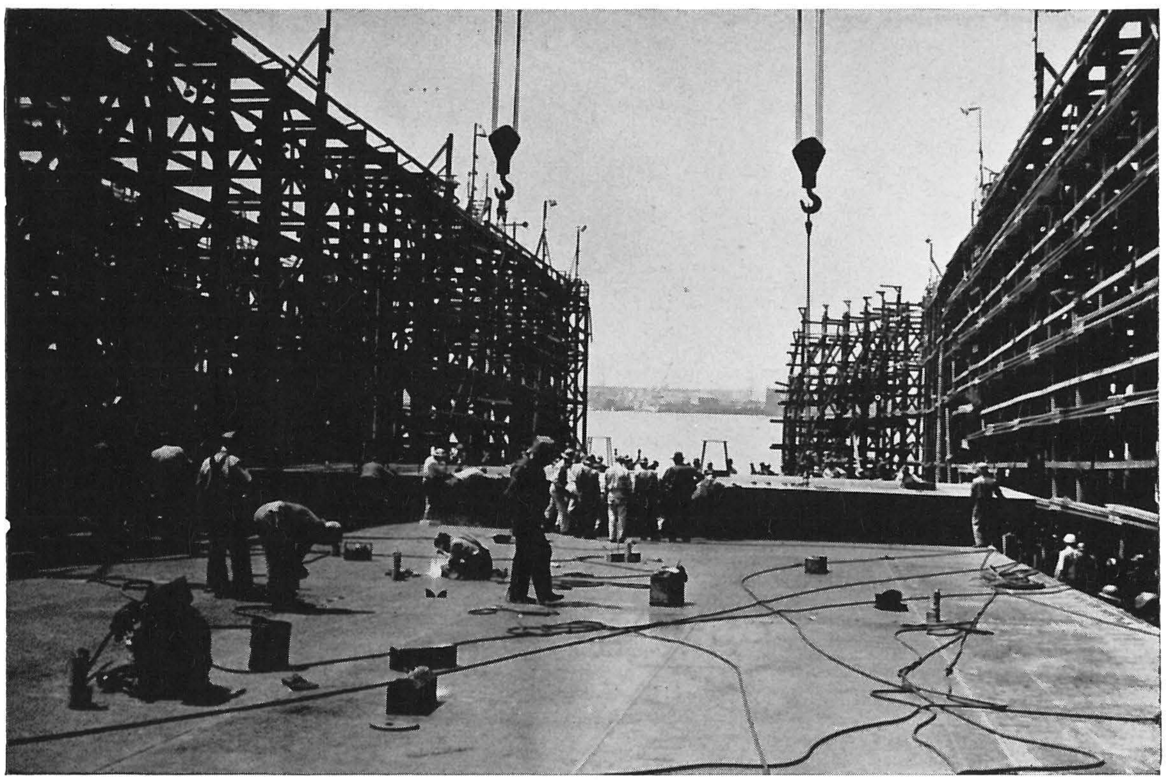
Next, the remaining floors are tacked and welded, two at a time, both ways from the center on each side of the vertical keel until all the floors and intercostals are welded. The vertical welds are step-welded; that is, one welder welds half way up while a welder on the opposite side starts his bead at the middle.

To keep the engine bed plate from buckling along the seams, ½″x6″ bars are set between the floors over the inboard and outboard edges and wedged down against the seams. These are left on until after the section has been turned and the unionmelt welding completed. The stiffeners between limber holes are used over the rest of the tank top as in the other sections.

The floor plates are welded to the tank top after the vertical welds are complete. The procedure is slightly different from the other floors. To keep the floors from pulling up from the tank top, the outer 6″ is welded on both sides, and then welding out from the outboard side of the engine bed plate, welds are made first on one side and then on the other, completing the weld on the second pass. The floor plates are then step welded from the vertical keel to the outboard edge of the engine bed. The intercostal flats are welded, and last of all, the vertical keel is welded to the rider plate both ways from the center.



Landing First Section of Double Bottom on Flat Bottom.

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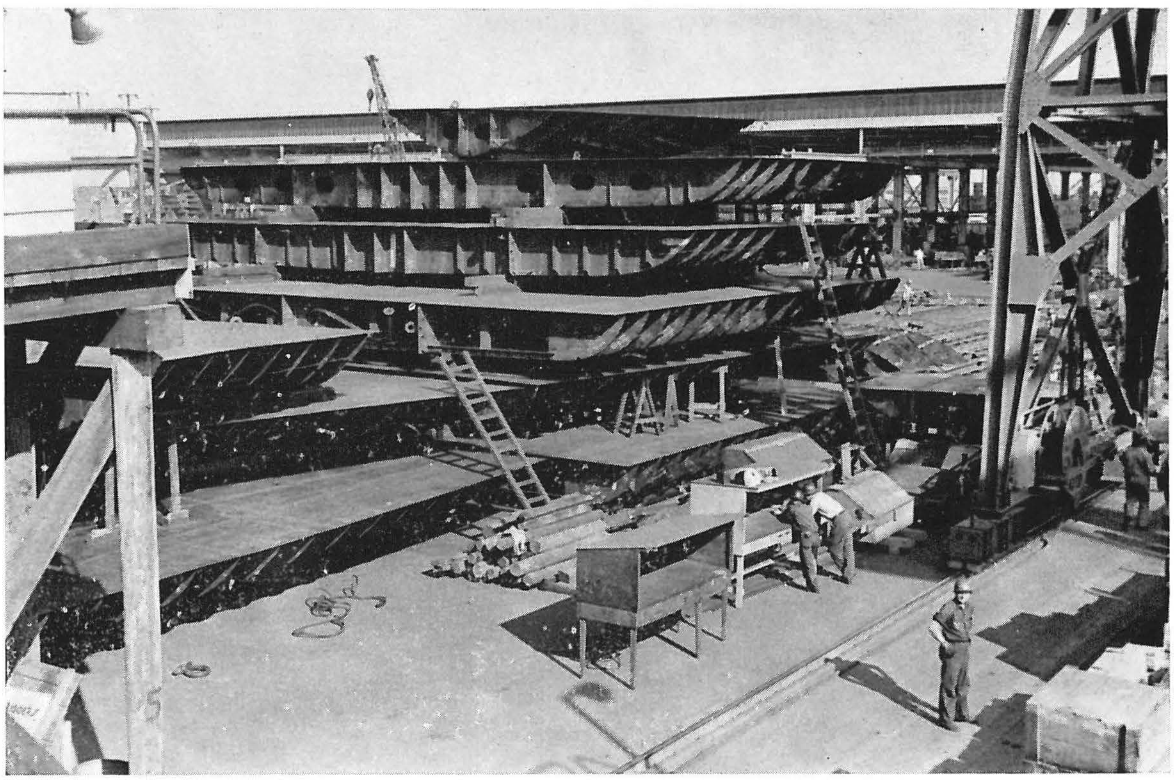

Completed Double Bottom Sections.

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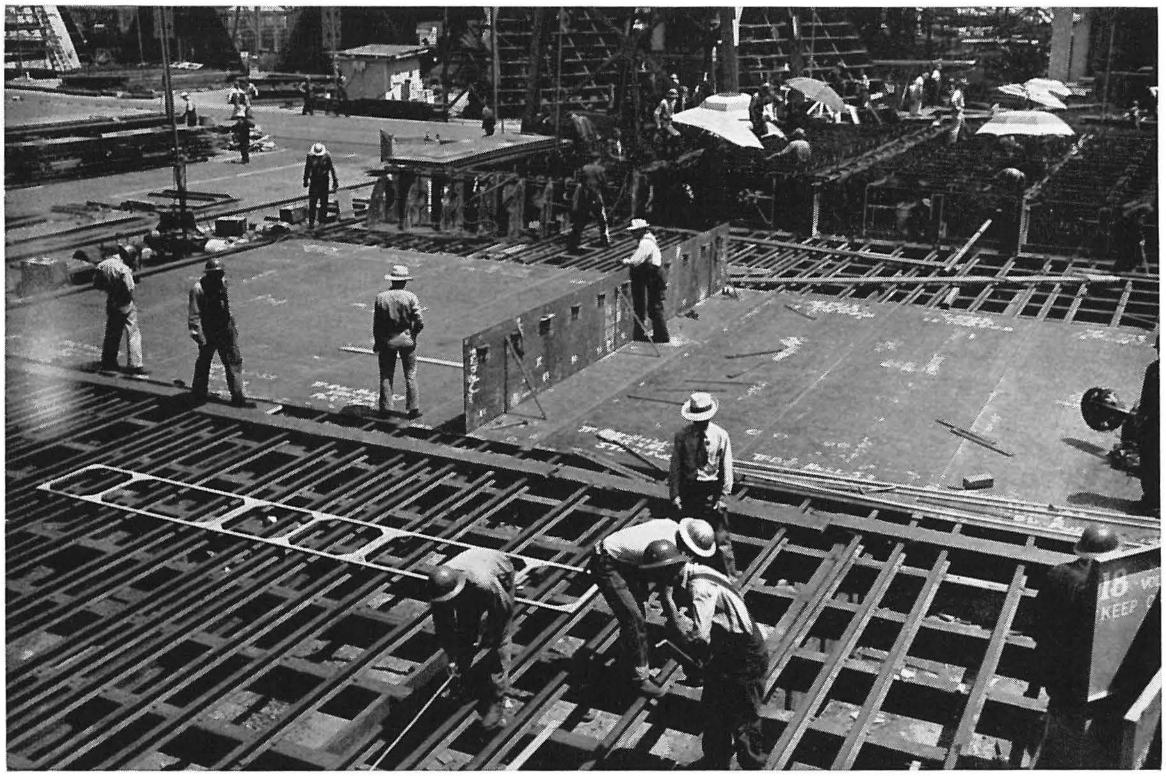

Tank Top and Vertical Keel in Place Ready for Floors.

spacing between floors at the butt of two vertical keel plates, and both the keel and rider plates are tacked at the butt. Then the tank top plates are pulled into place and tacked. The longitudinal seams are joined, and any squaring is done at the butts. As the plates are pulled into place, they are tacked. It used to be the practice to pre-assemble the tank top plates on each side of the rider plate at a unionmelt pre-assembly skid and then transport them in long floppy sections to the skids. It has since been found more practical to assemble the plates on the way skids and unionmelt weld them in place.

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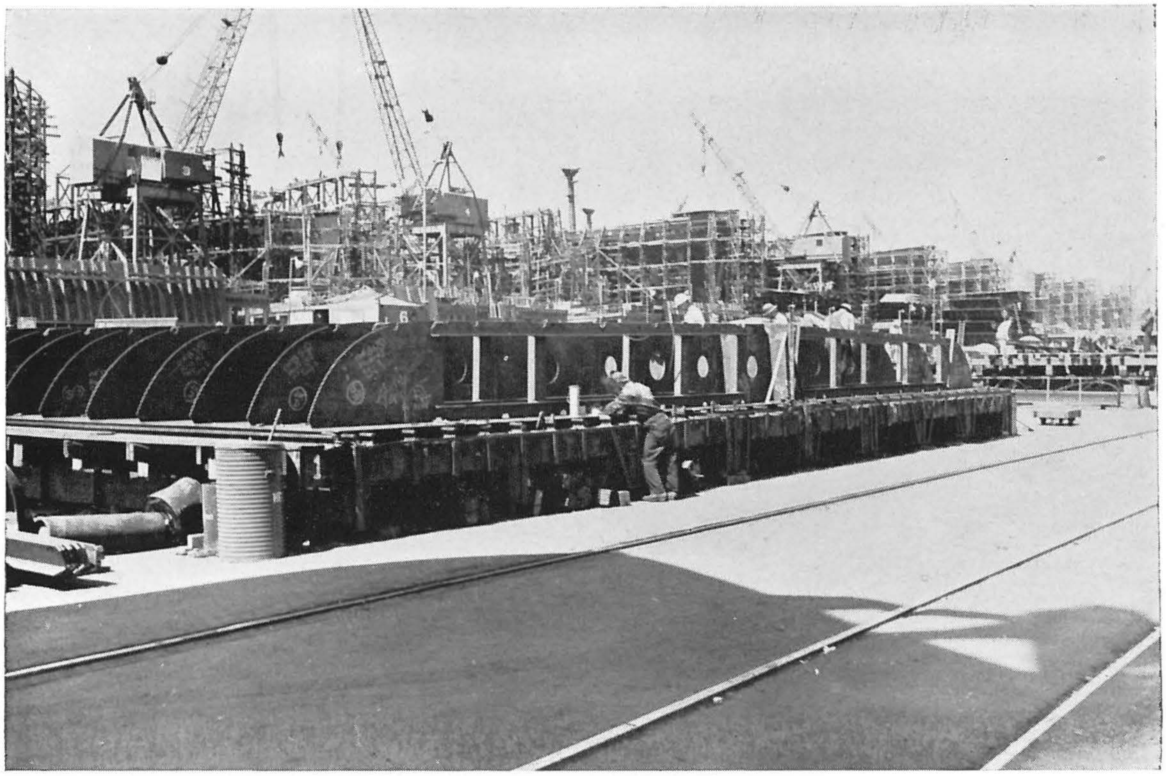
As soon as the unionmelt welding is completed, the layout men locate the floor, girders, drain wells, and buttock lines on the tank top. Fitters then set and plumb the floor plates, checking the buttock lines on the floor against the layout buttock lines to see that they are within ⅛″ of each other.



Double Bottom Section Before Turning.

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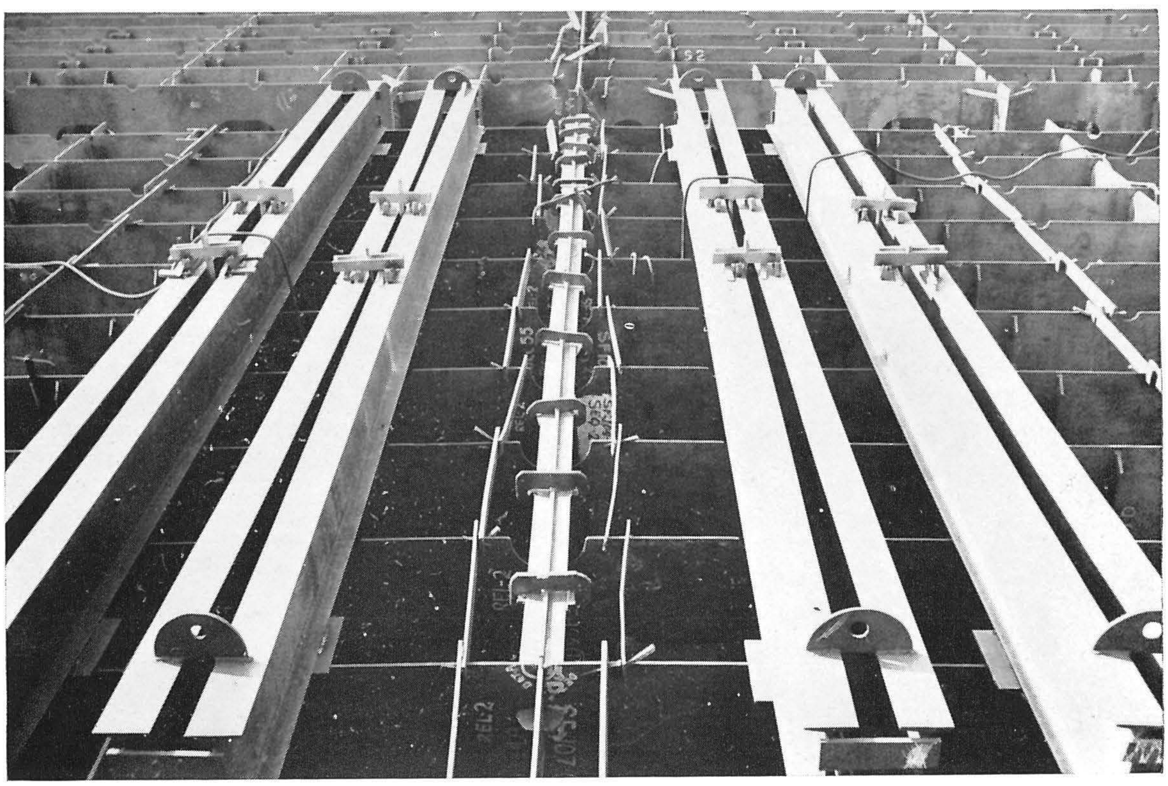
Side View Showing Floors, Stiffeners on Tank Top Plate, and Bracing Between Floors.



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The layout is made, and the floors and intercostals are set and tacked to the tank top, but not to the vertical keel. This section is not shimmed along the line of the vertical keel and the rider plate, but the strongback along the top of the vertical keel is placed before the welds to the keel progress very far.

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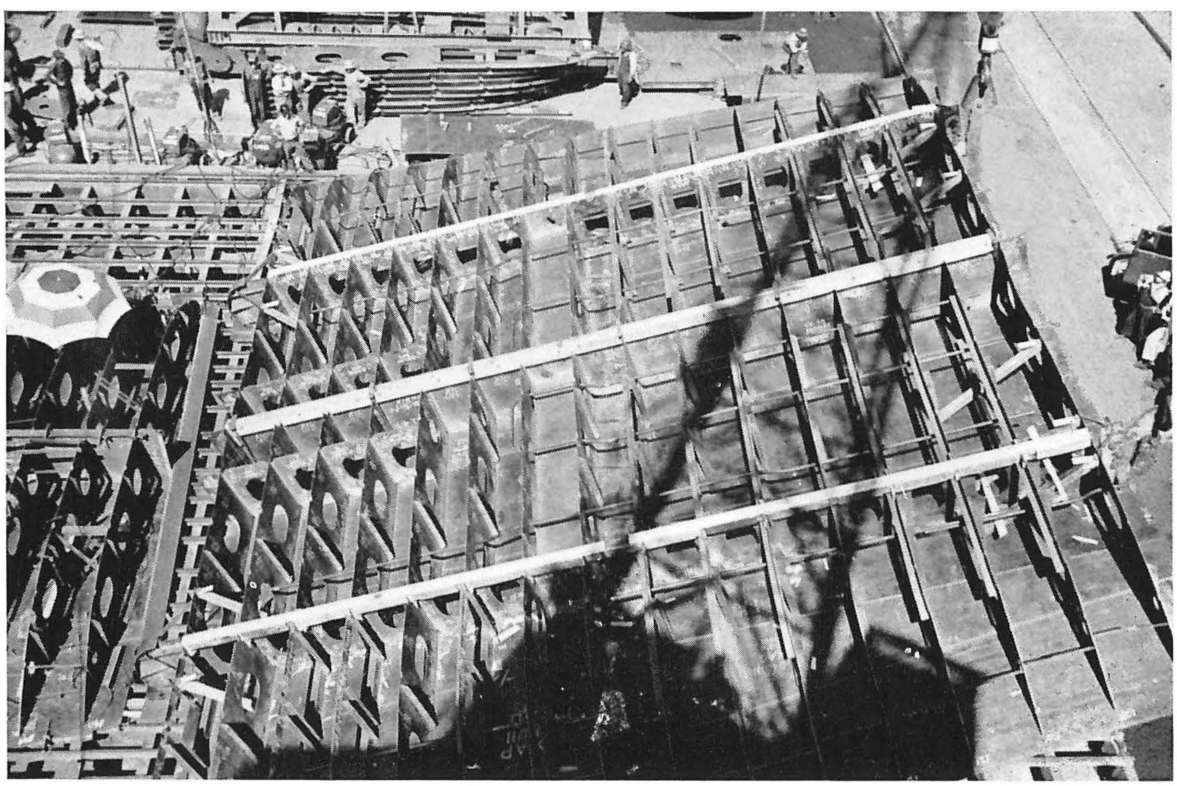

Section Being Lifted for Turning. Note Rollers At Left and Lifting Links At Right.

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To keep the engine bed plate from buckling along the seams, ½"x6" bars are set between the floors over the inboard and outboard edges and wedged down against the seams. These are left on until after the section has been turned and the unionmelt welding completed. The stiffeners between limber holes are used over the rest of the tank top as in the other sections.

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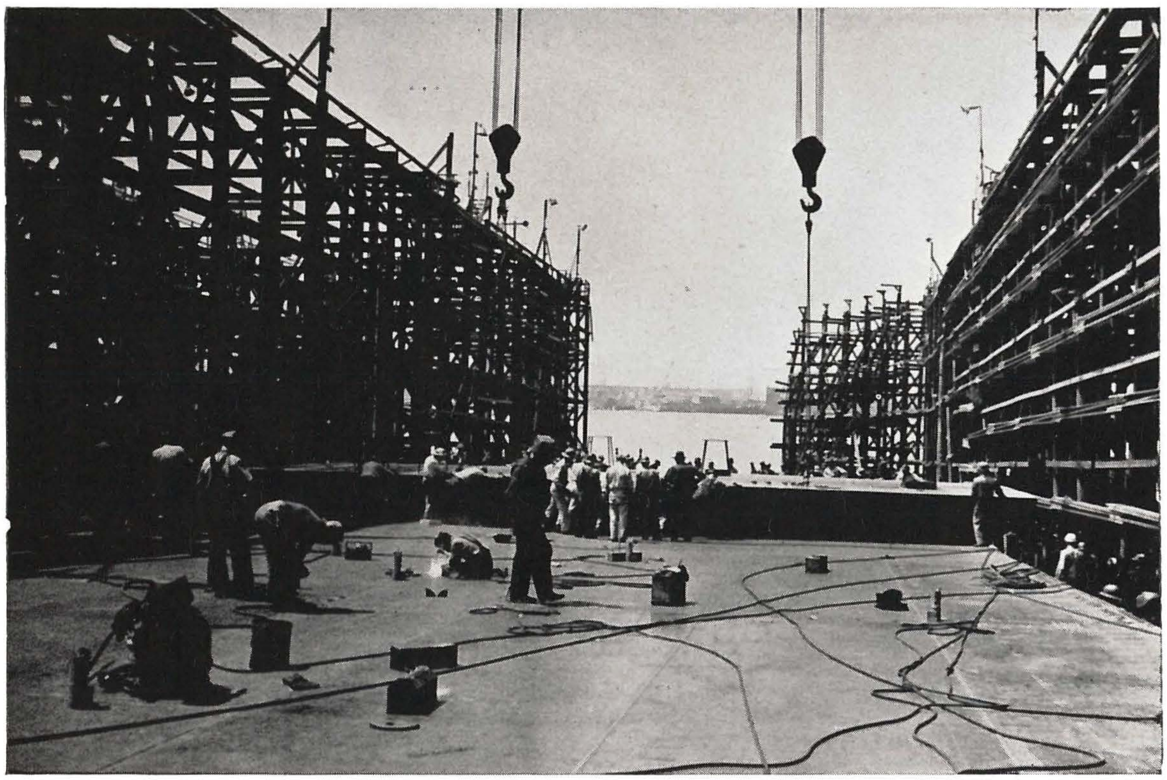

Landing First Section of Double Bottom on Flat Bottom.

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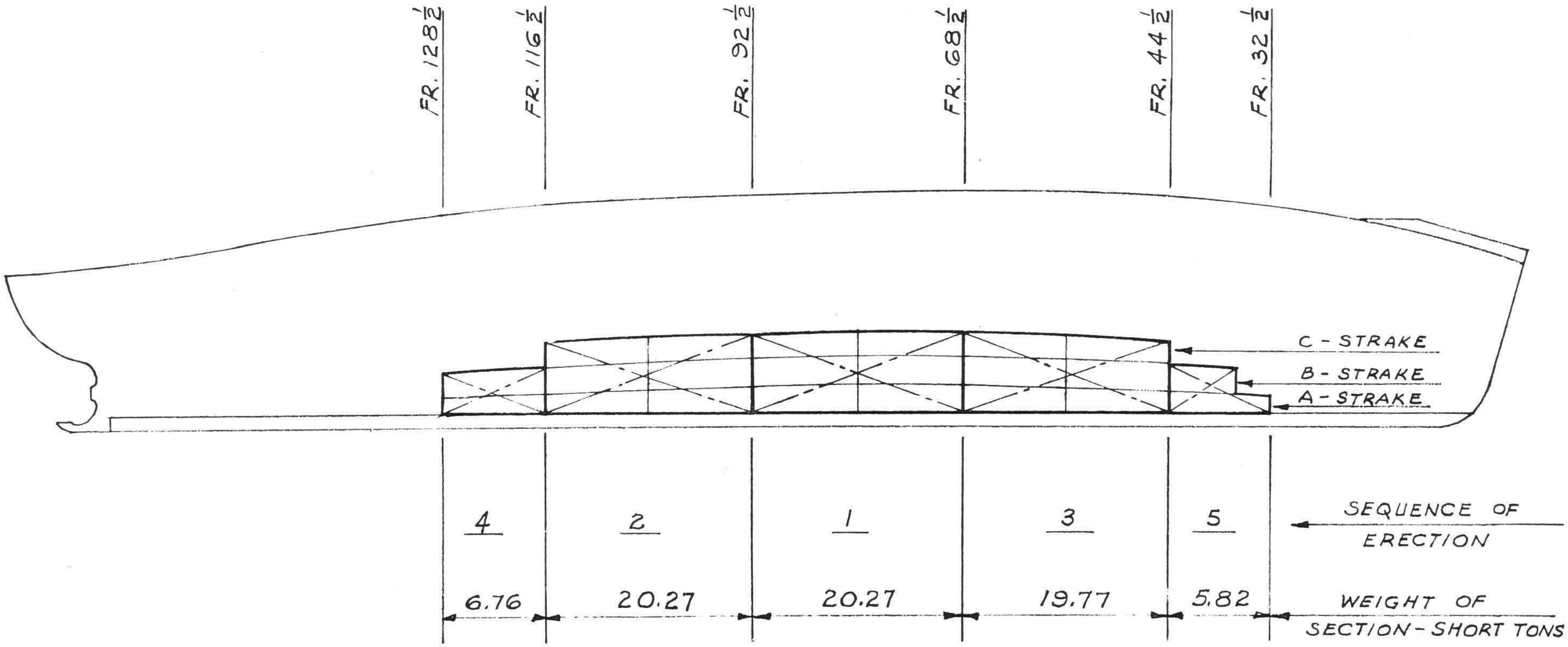
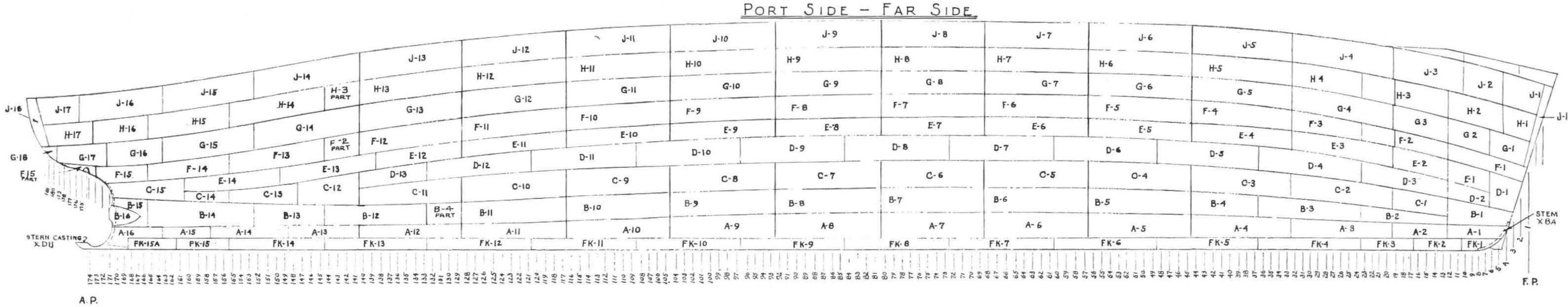


U.S.M.C. DESIGN EC2-SC-1 CARGO VESSELS

CALIFORNIA SHIPBUILDING CORPORATION
TERMINAL ISLAND

BOTTOM SHELL ERECTION SECTIONS

Port Side – Far Side



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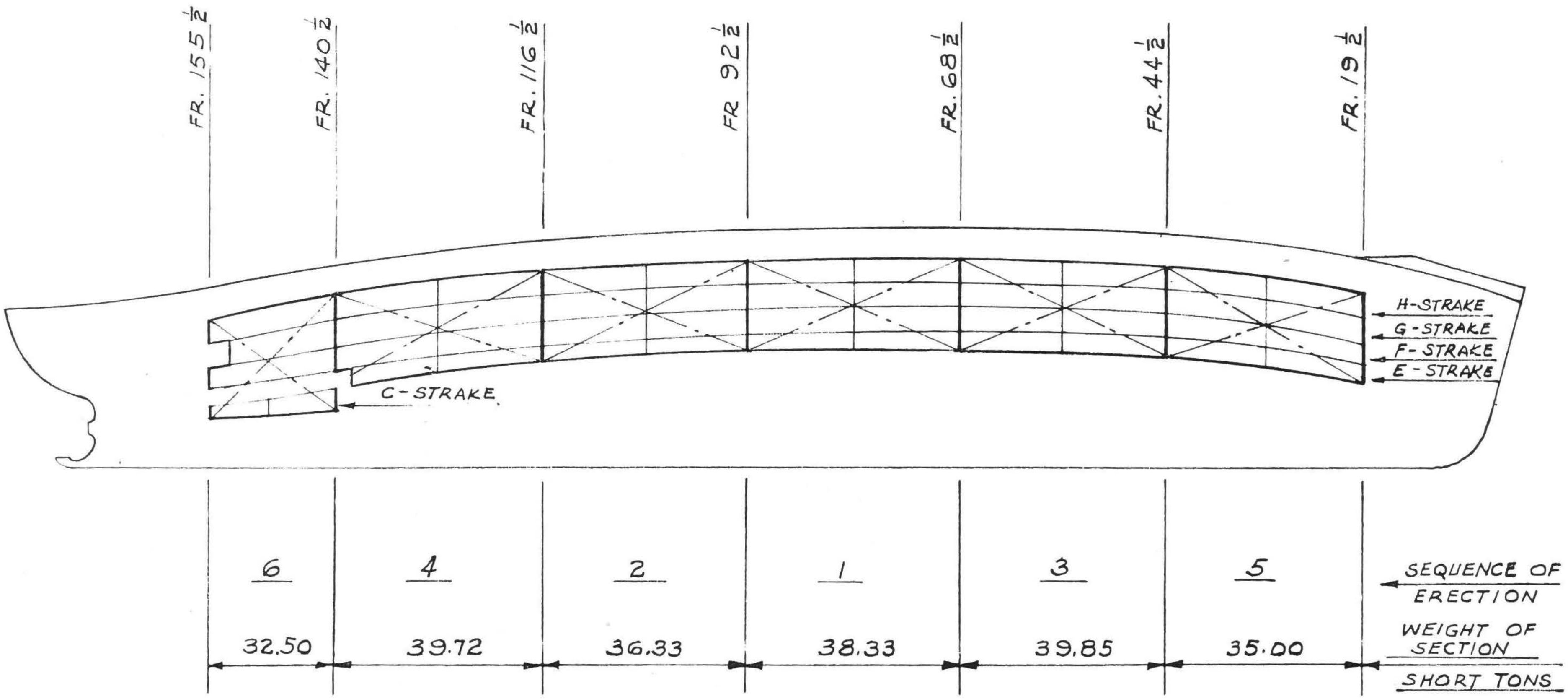
CALIFORNIA SHIPBUILDING CORPORATION
TERMINAL ISLAND

SHELL EXPANSION



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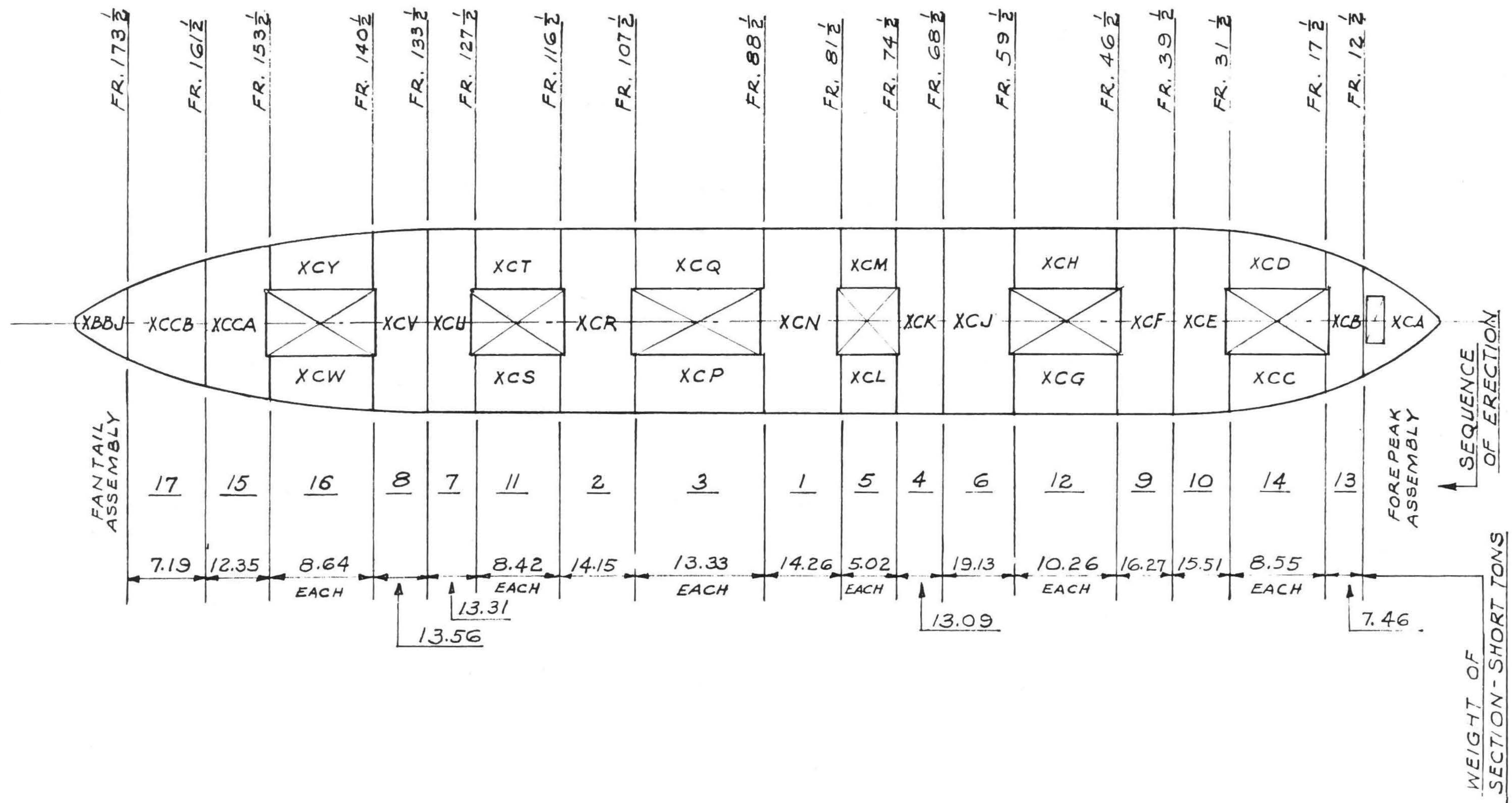
CALIFORNIA SHIPBUILDING CORPORATION
TERMINAL ISLAND

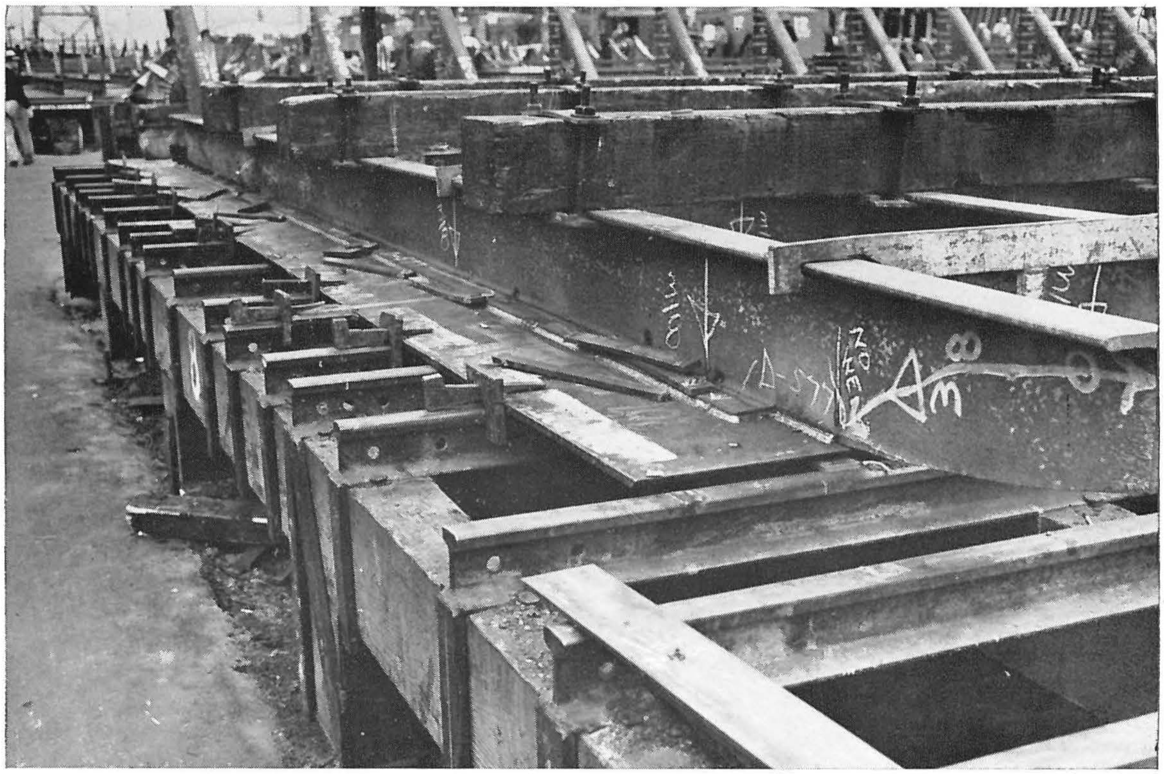
SIDE SHELL ERECTION SECTIONS



U.S.M.C. DESIGN EC2-SC-1 CARGO VESSELS

CALIFORNIA SHIPBUILDING CORPORATION
TERMINAL ISLAND

SECOND DECK ERECTION SECTIONS



Edge of Side Shell Section Dogged Down Over ⅝″ Flat Bar to Counteract Effect of Weld at Frame. The ½″x1″ Diagonal Bars Have Just Been Knocked Off. Note T Stiffener Between the Frames.

After the plates from the frames out to the edge have been deformed downwards, ½″x1″ bars are tacked at the top of the frame and out to the edge of the plate to help hold the edge down. At the bottom of frame 115, the butt seam curves up off the skid and cannot be handled like the rest of the edges, in this case the lower corner of the plate is pulled down 1″ with a chain and ratchet. The 1″ is measured from a straight edge laid over the adjoining frames.

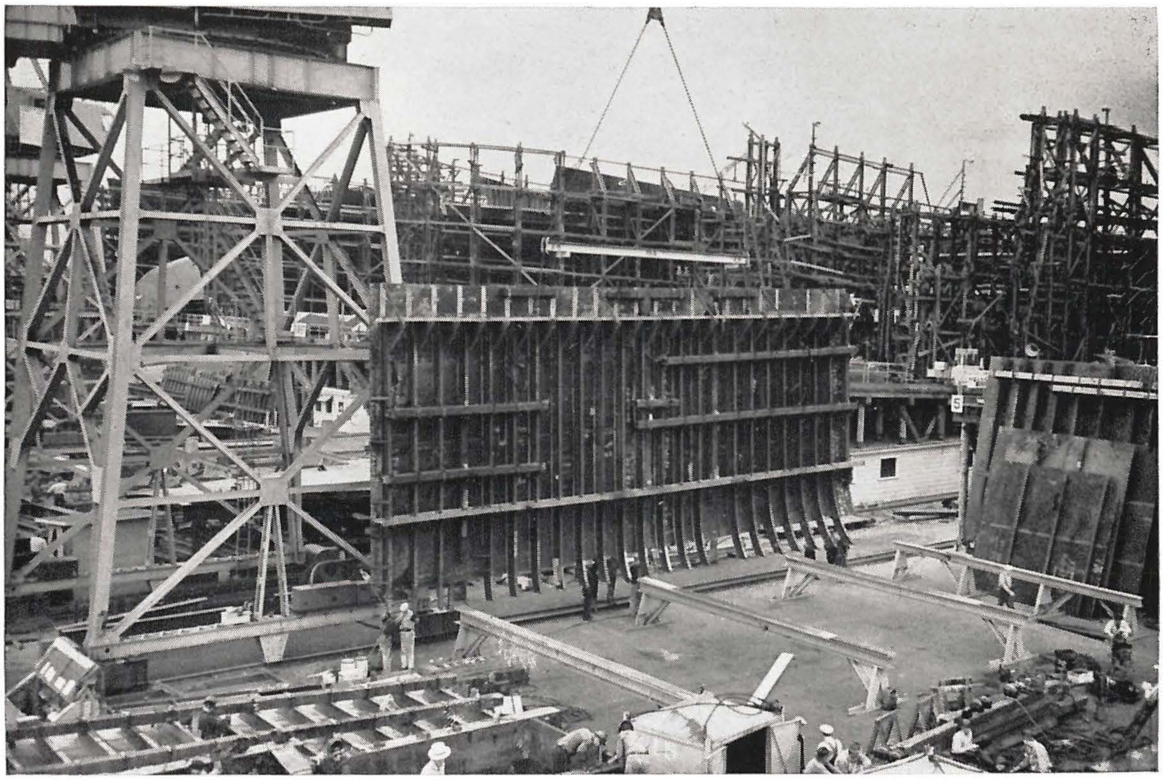
A row of T bars is placed along the lower edge of the E 10 plates at the welded frames, and the plate is wedged down to overcome the curl. Wherever a riveted frame ends over a bulkhead, or the flange is cut to allow space over a tank top, the lower several inches are welded on the skids to prevent curling of the flange during riveting. Thus at frame 96, the lower 6″ is welded on both sides.

The welding of the frames is done in steps to keep the section as cool as possible. Starting at the center of a frame, the welds are staggered both ways to the end. A second pass is made to complete the continuous weld on both sides of the stiffener.

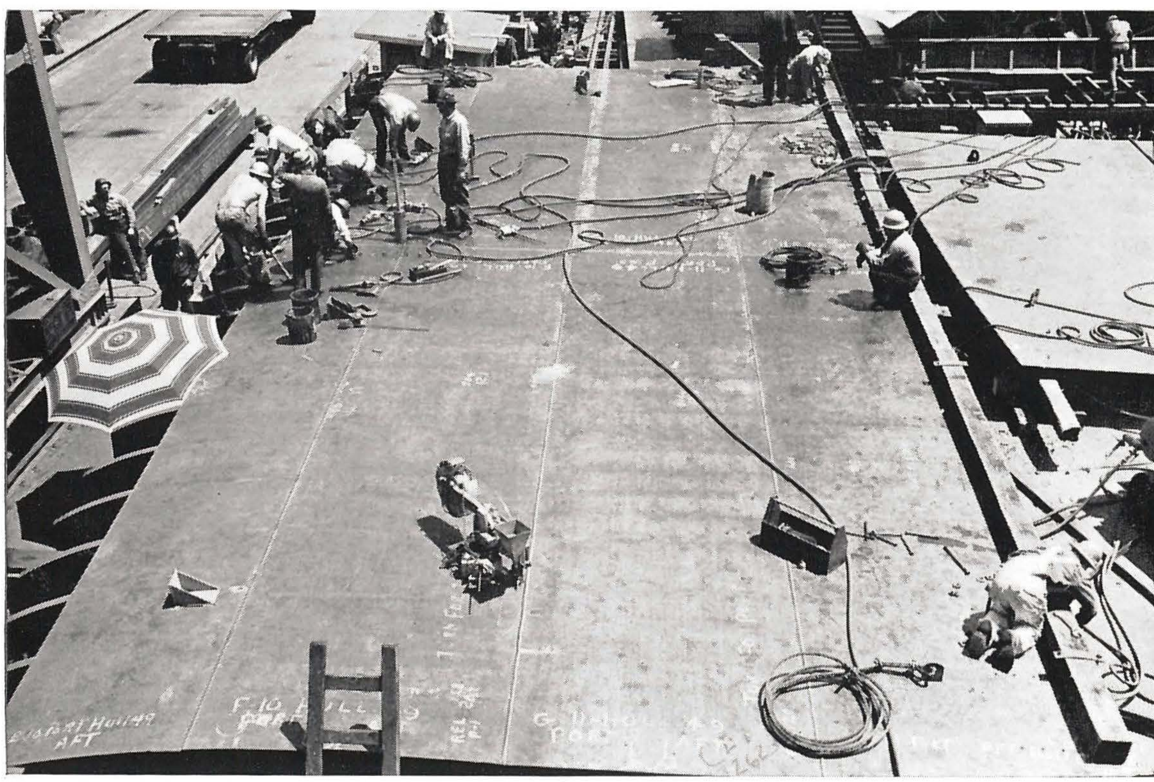
There is no manual weld on erection sections 3, 4, and 5, except for parts of the seams where the slope is too great for the unionmelt machine. There the seam is chipped out and manual-welded.

After the bolting up and welding are completed, the section is turned over and set down on horses on which blocking has been placed to fit the curve of the shell. Chippers remove the backup straps and clean the unionmelt seams where necessary. The unionmelt weld of the outside is made, and the shipwrights put on the shoring lugs.

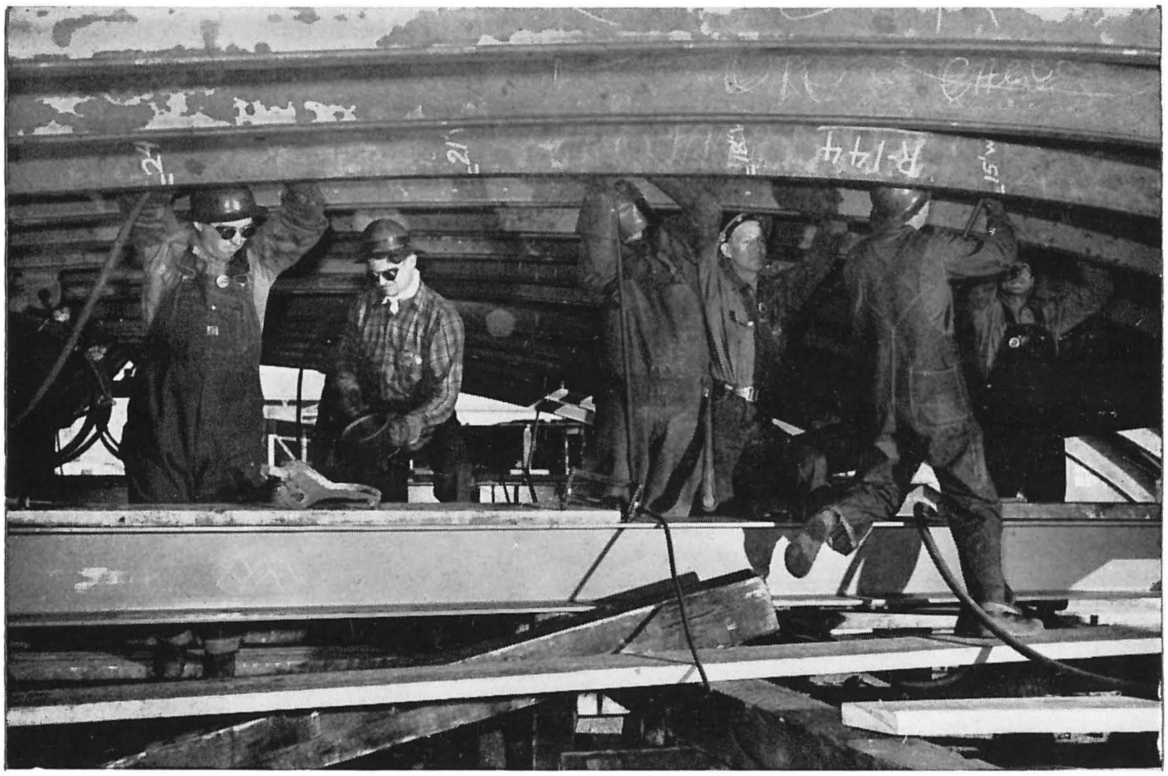
A crew starts reaming the rivet holes to 15/16°. ⅞″ bolts are run up tight with an impact wrench to obtain a maximum clearance of 15/1000″ between the shell and the frame. If the bolts alone do not make a satisfactory fit, usually a No. 80 rivet gun will lay the frame up the rest of the way. However, in some cases it is necessary to use a heavier gun or to heat the frame before it is laid up and then to tack it to the shell.



Laying Starboard Erection Section 2 on Horses Before Riveting



Completing Riveting of Side Shell Section.



Laying Up and Riveting Frames To Shell.

After the frames are laid up tight, the holes are reamed and the frames are riveted to the shell. The shipwrights add a timber stiffener to the outside edge, and the section is ready to be put in place on the hull. The side shell sections cannot be stored very readily without distortion, and the skid assembly is scheduled so that they can be lifted directly to the hull. The shell sections are laid down in such a way that when the crane picks them up, they are in position to land on the hull without any further turning.

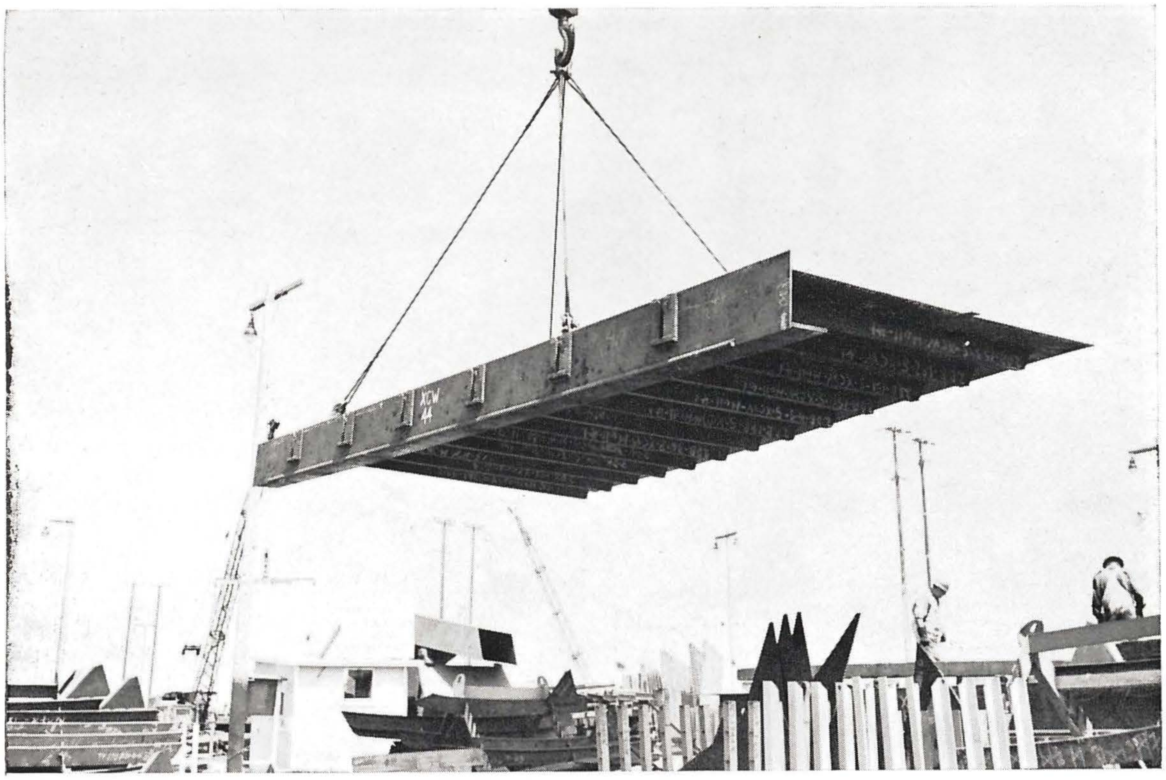
As seen in the illustration, the second deck beam brackets are welded to the side frames in the shop and are therefore included in the side shell section assembly.

No. 1 erection section has no wild stock on the butt edges, and the other sections are trimmed to it during erection on the hull. Each of the other sections have ½″ of wild stock on the edge towards midship. The top and bottom are cut to neat lines in the shop.

Sub-Assembly of Second Deck Sections

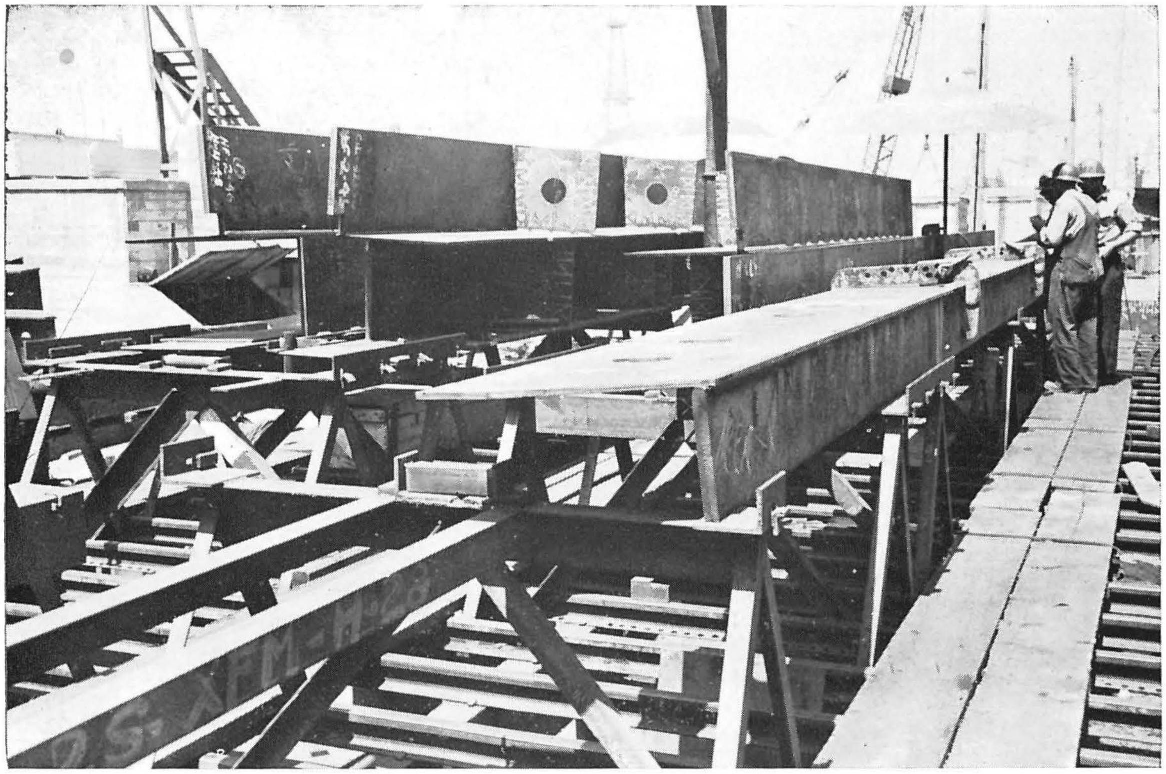
The second deck between the forepeak and the fan tail is divided into twenty-three sections, which are assembled on the skids east of way 14. Each sub-assembly is complete with deck plate, deck beams, girders, and hatch end beams ready to be set on the bulkheads and on the frame brackets.

The plates are laid on the skids, pulled together, and tacked. The butts and then the seams are unionmelt welded, both ways from the center. Next, layout men locate deck beams, girders, and hatch end beams, if any. The hatch edges of the sections around the five holds are trimmed to size; but sections XCP and XCQ at the engine casing are not trimmed. Then the fitters set the deck beams and the girders. They are tacked, and the production welding can start at the end away from the hatch end beams. On section XCB, the two angles that help support the ventilators are welded to the deck beams before the deck beams are set, to eliminate welding in a pocket.

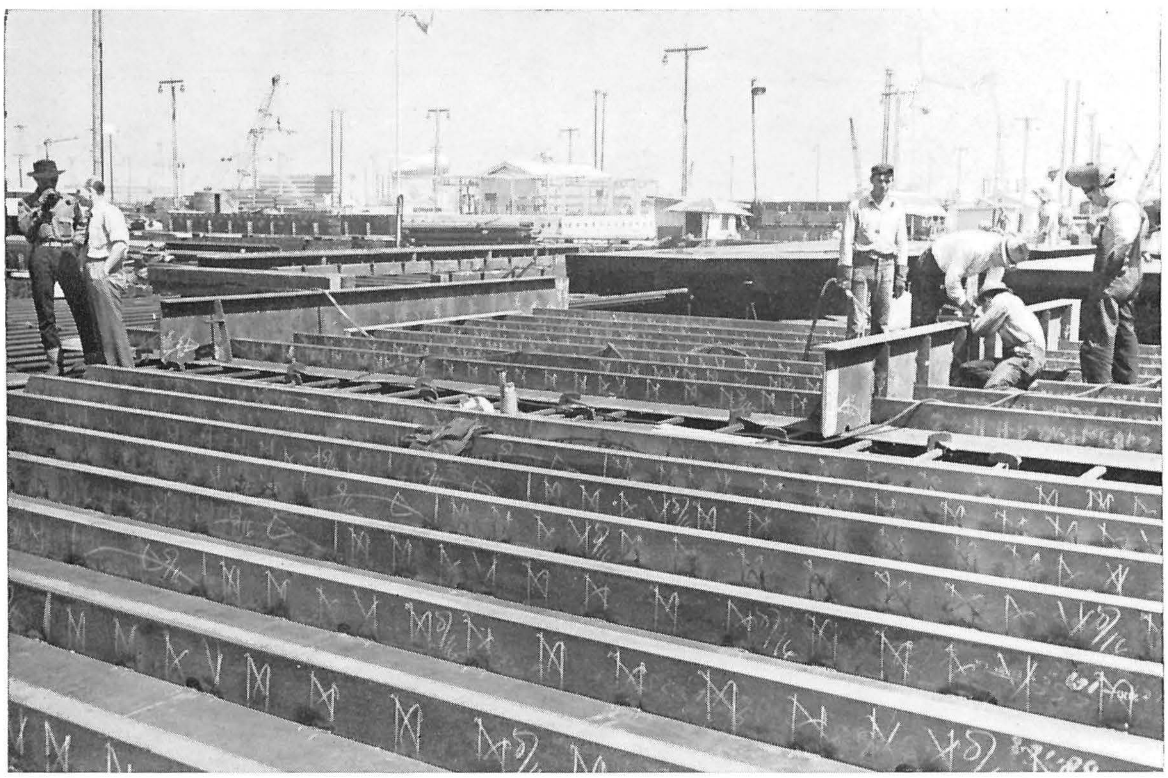


Longitudinal Second Deck Section Going to Hull

Unionmelt Welding Second Deck Section.



Pre-Assembly of Second Deck Hatch End Beams.



Transverse Second Deck Section on Skids. Note Weld Layout Marks.

The longitudinal hatch side girders are pre-assembled in the shop and are set in place after the deck beams and girders are tacked. The transverse hatch end beams are pre-assembled in three sections in the shop and then assembled into one long beam at the skids before being set on the deck section.

It was formerly the practice to fit the individual pieces of the hatch end beam onto the section, but recently a small assembly jig has been built at the end of the skids where the three parts are welded together to save fitting and vertical welding at the section. This operation is described later.

After the hatch end beams have been tacked, the entire section is welded, working both ways from the center. Also the final weld on the hatch end beam is made. The timber bracing is placed, the section is turned over, and the unionmelt welding of the deck plate completed. The inside of the deck beam flanges are welded to the girders, and the inside of the girder flanges are welded to the hatch end beams.

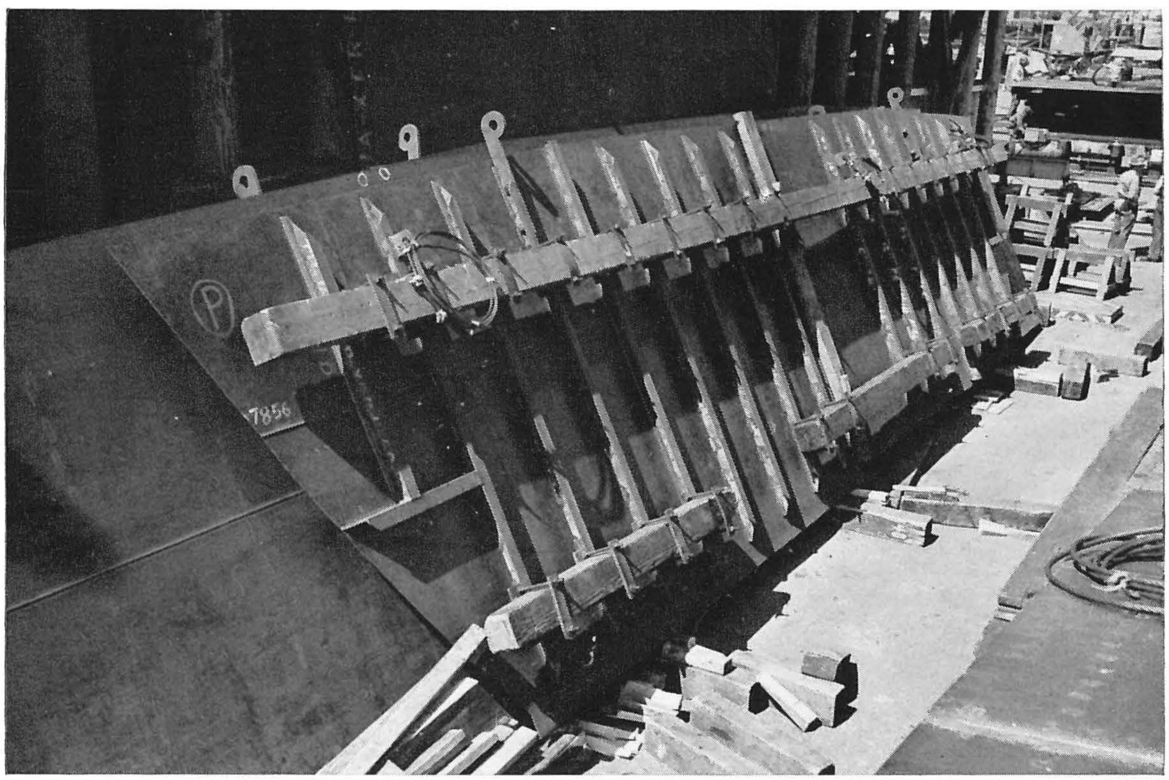
Layout men outline the edges of the deck plate which are then trimmed with the radiagraph torch.

PRE-ASSEMBLY OF HATCH END BEAMS

The three pieces of the longitudinal hatch beam are set to line on the jig with the web flat and the face plate vertical. The inside of the butts of the web are welded, and the short fillet welds between the web and the face plate at the joints are made. Then the beam is turned 90° to bring the inside of the face plate flat, and the face plate butts are welded. The beam is turned 90° again, and the outside of the web butts are chipped and welded. The outside of the face plate butts can be chipped here or after the beam is placed on the section.

Sub-Assembly of 'Tween Deck Bulkheads

The seven transverse bulkheads between the second and upper decks at frames 12, 39, 68, 88, 108, 134, and 162 are sub-assembled at the east skid, as are the second deck sections.



'Tween Deck Bulkheads Stored at Head of Way.

The bulkhead plates are laid down on the rails and pulled together. If any of the butts or seams are not tight enough for unionmelt welding, they are parallel burned and a tight joint obtained. The unionmelt weld is made both ways from the center on the butt and then on the seams.

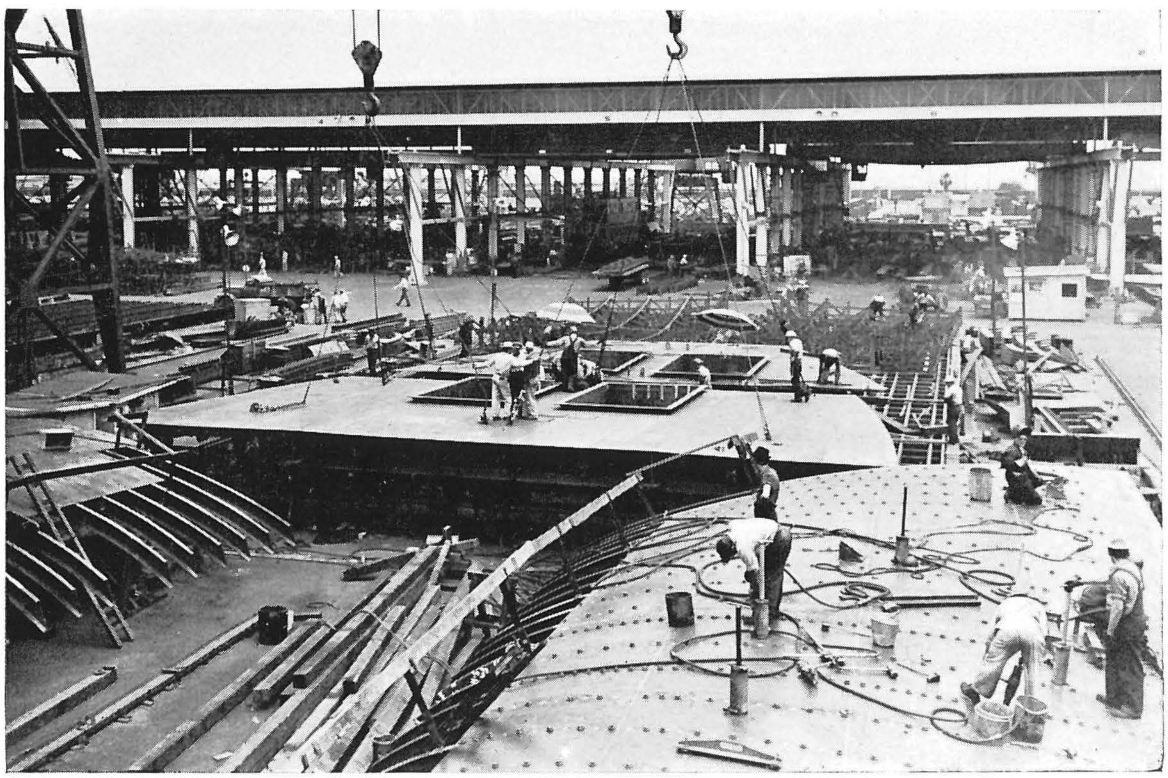
The stiffeners are set, tacked, and production welded. The timber stiffeners are placed, and the bulkhead is turned over and unionmelt welded. Using trimming template, the layout men locate the edges, which are then trimmed.

Sub-Assembly of Forward Deep Tank Flats

The four forward deep tanks extend the full width of the hull from bulkhead 12 to bulkhead 39 and are formed by the tank top of the double bottom, the deep tank flats XBBL aft and XBBK forward, the side shell port and starboard, and the transverse and longitudinal bulkheads.

After the double bottom and bulkheads have been put in place on the hull, the construction of the forward deep tank flats XBBL and XBBK is started on the skids so that after the welding is completed on the hull the tank top assembly of the forward deep tank will be ready for installation.

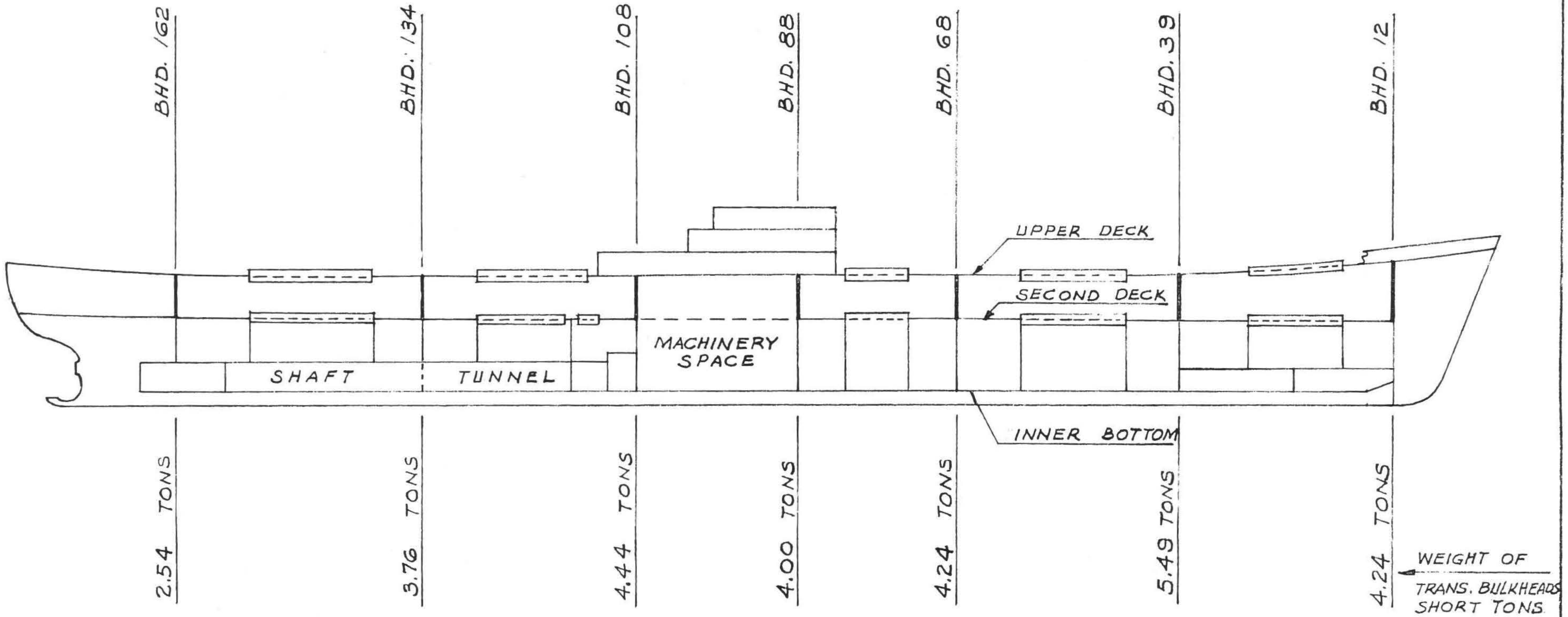
The plates are pulled together, fitted, tacked, and unionmelt welded. After the unionmelt weld is complete, the layout men locate the hatches, beams, and girders; and the hatches are cut with the radiagraph. Both hatch openings should be carefully checked to see that the sides are square.



Lifting Completed Section.

Next the unionmelt seam is chipped flat at the beams, and the beams are distributed. The plate is dogged tightly to the rails to prevent distortion. As soon as the beams are set they are tacked, and production welding starts at the aft end of XBBL so that the DTG-3 girders can be set at the same time as the forward beams. The inboard end of the beams should be welded before the girder is set.

When the beams and the girders have been welded, the section is timbered and raised onto cribbing to provide clearance for setting the hatch coamings. It is well to check that the cribbing is



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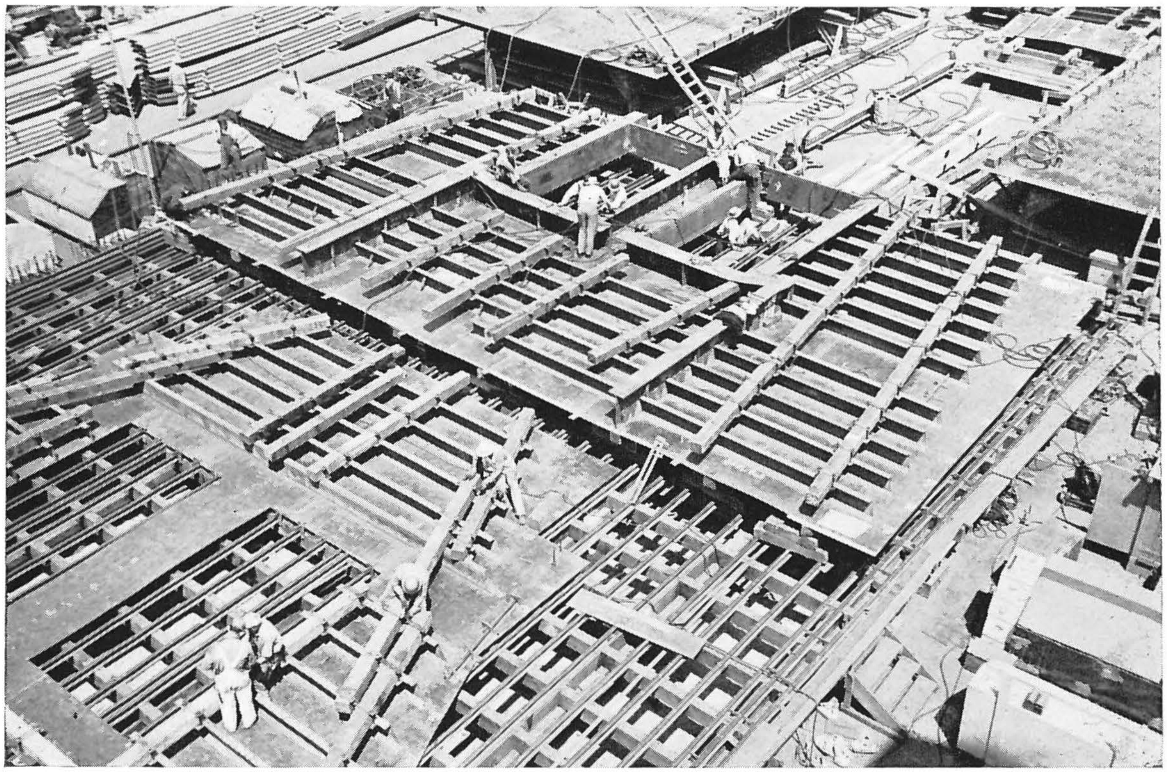
TRANS. BULKHEADS TWEEN DECKS

level so that the coamings will fit properly. On the aft section XBBL the coamings are set in the order DTG-4, 2-1, 5, 1; and on the forward sections XBBK, in the order DTG-6, 2, 5, 1. After the deep tank beam brackets have been fitted to their proper places, the watertight hatch brackets must be fitted between the angle of the coaming and of the deck. After the hatches have been fitted and tacked, they are welded. All of the verticals are welded first and then the flats around the hatch. The water stops and the hatch corners are very carefully welded to secure a watertight fit. ½" bars on edge vertically are used as strongbacks to keep the hatch coamings from warping at the weld to the deck.



Setting Hatch Coamings.

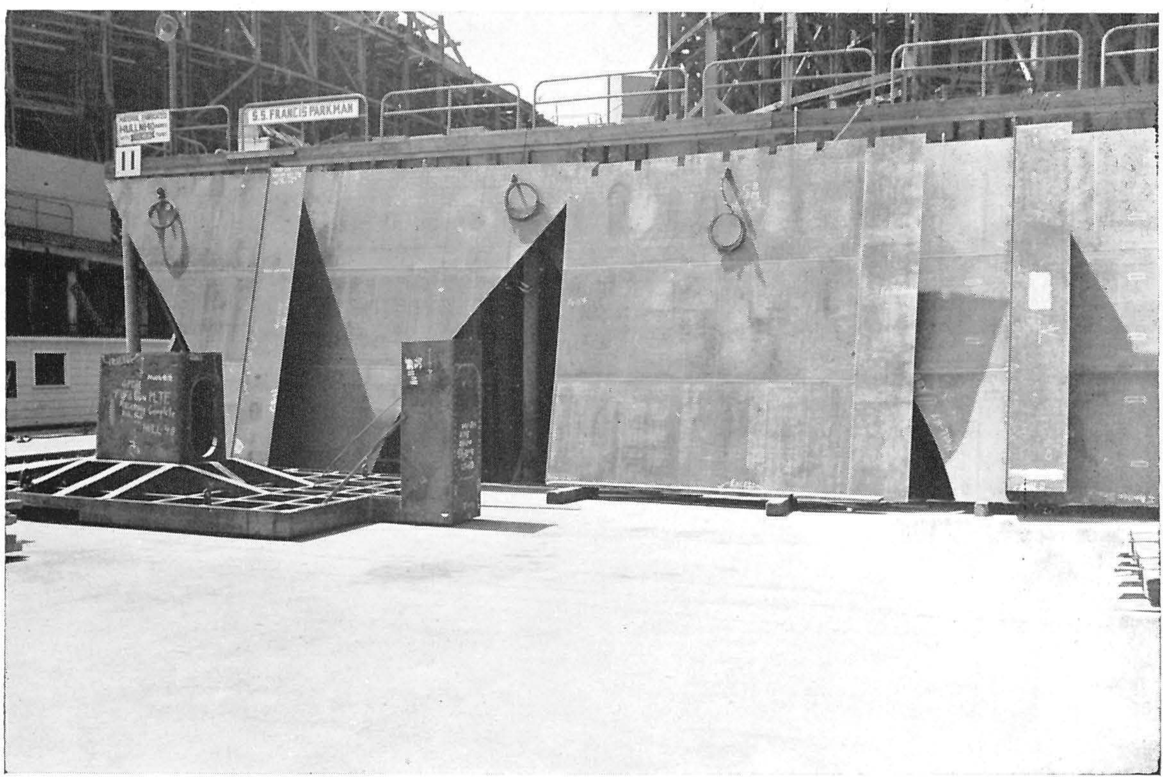
After all of the welding is completed, the center line slot for the center line bulkhead is cut through the beams. The aft section in particular is quite heavy, and it must be carefully timbered before it is turned. The crane turns the section over, and the unionmelt welding of the other side of the seams is completed. Layout men complete the layout, and the plate is trimmed to its final size.

Before the section is sent to the hull, the hatch angles are faired, if they have warped, so that the covers will fit properly on the ways. Lifting lugs are added, and the section is ready to be sent to the ways.

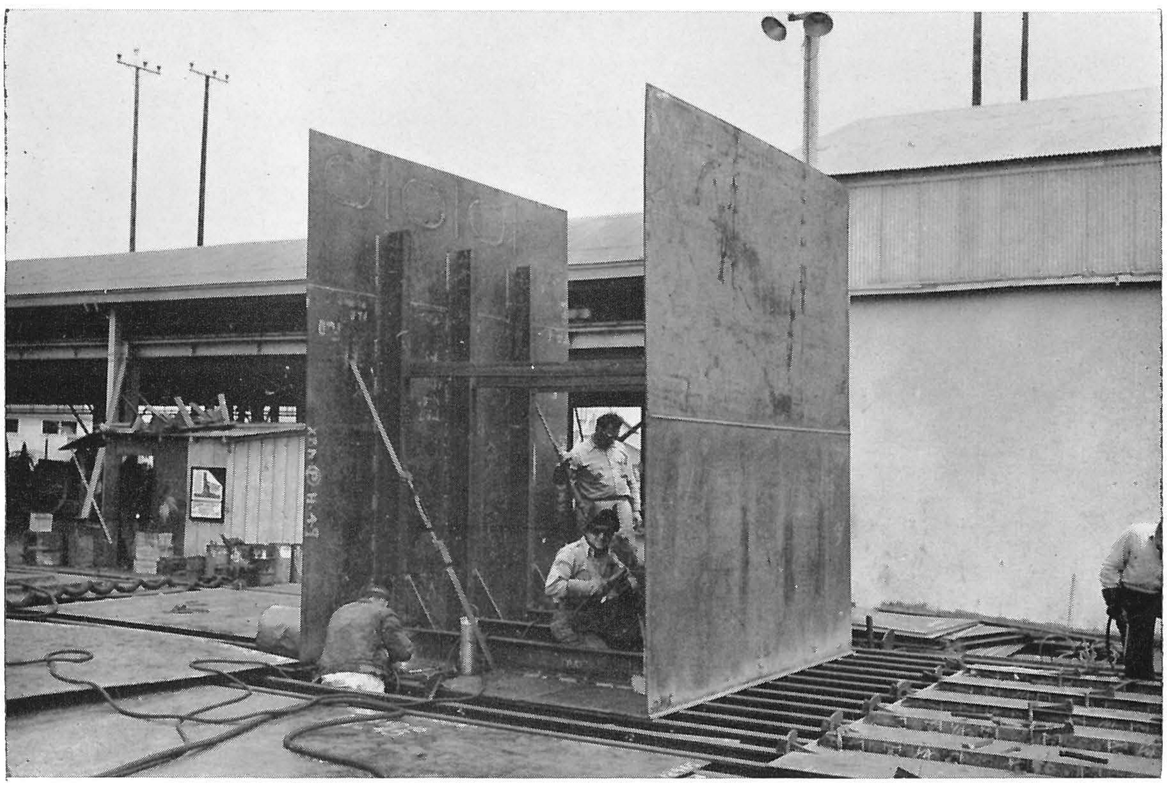
A study is being made of the possibilities of a slight change in the design of the hatch coamings to permit assembling them in two pieces. This will eliminate the necessity of raising the deep tank flat off the skids to set the coaming. It will also permit starting assembly of the coaming at the same time as the plate. This will save considerable time in the sub-assembly.

Sub-Assembly of Miscellaneous Bulkheads, Flats, and Tanks

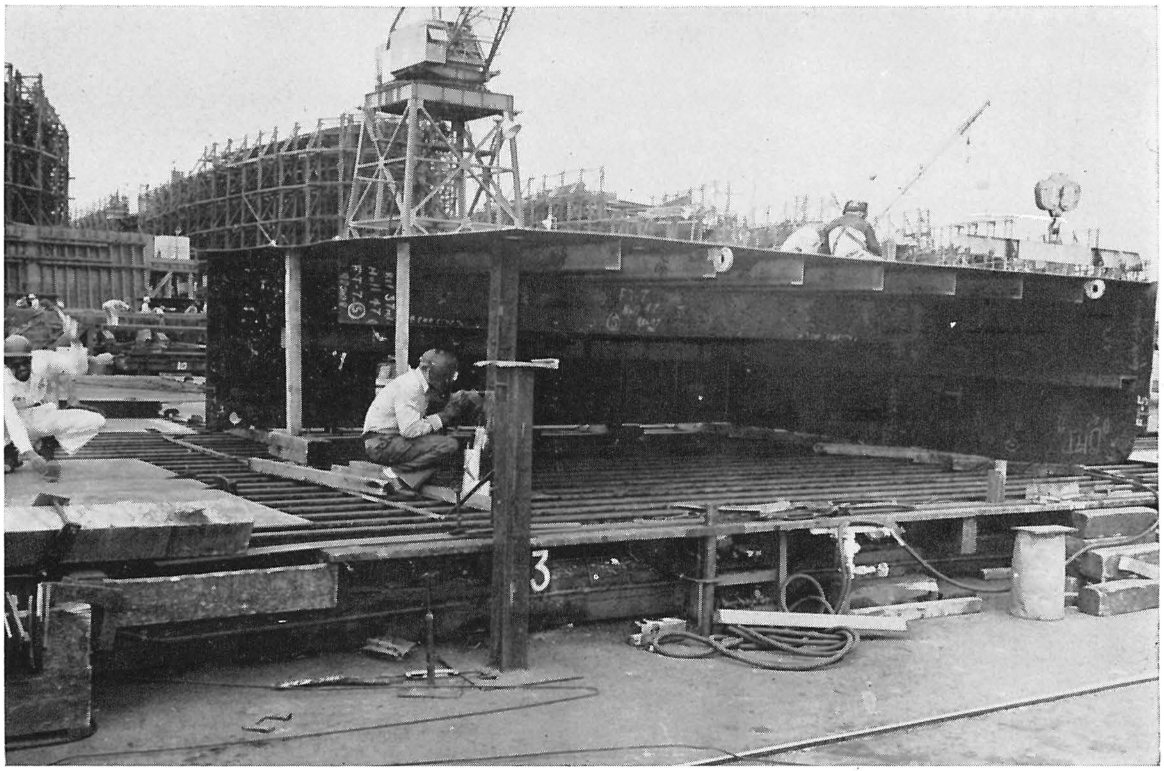
The center line bulkheads, miscellaneous bulkheads and steel flats below the upper deck, thrust recess, fresh water tanks, and fuel oil settling tanks are assembled at the east assembly skid. The



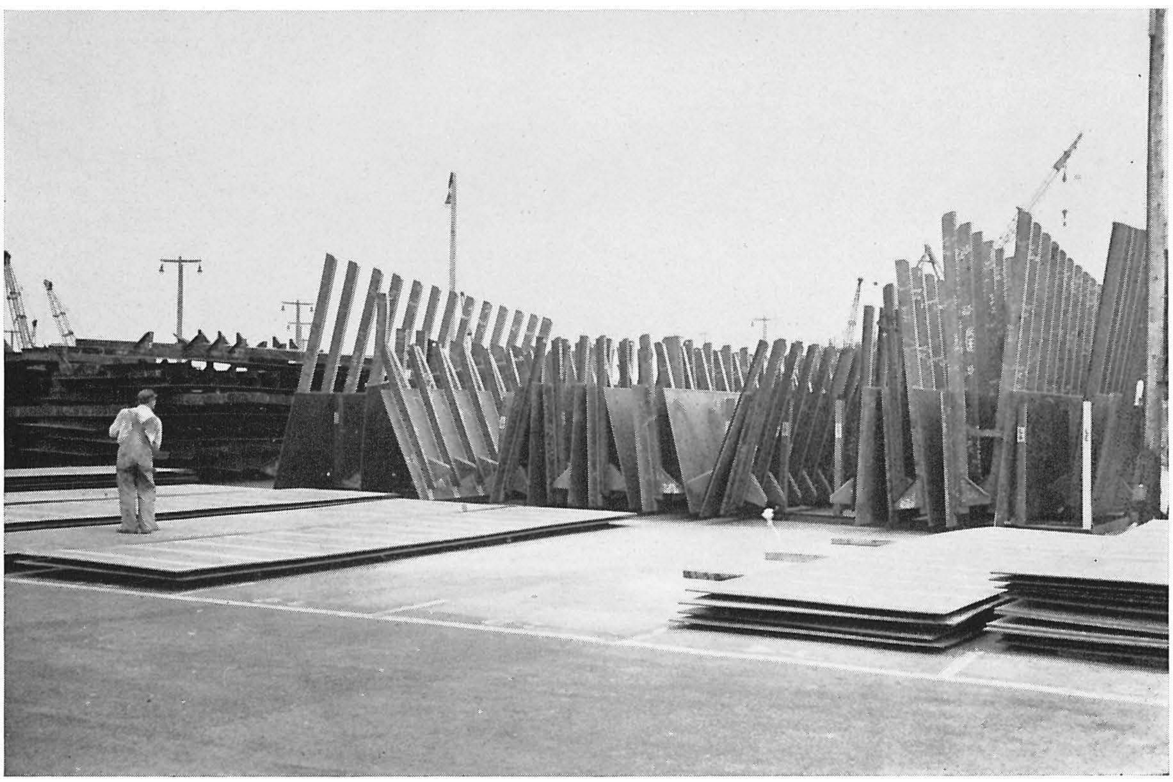
Center Line and Transverse Bulkheads Ready for Hull.



Thrust Recess Sub-Assembly.



Fuel Oil Settling Tank Sub-Assembly.



J Strake Plates with Frames in Storage Rack.

procedures of fitting, layout, and welding are the same as for transverse bulkheads and other larger sections. The top and sides but not the aft end of the thrust recess and the top and sides of the fuel oil settling tanks are assembled together before being taken to the hulls.

Sub-Assembly of the J Strake

The sheer strake, which in these vessels is the J strake of the shell plating, is erected on the hull in individual plates with the frames bolted to the plate. The riveting is done on the hull.

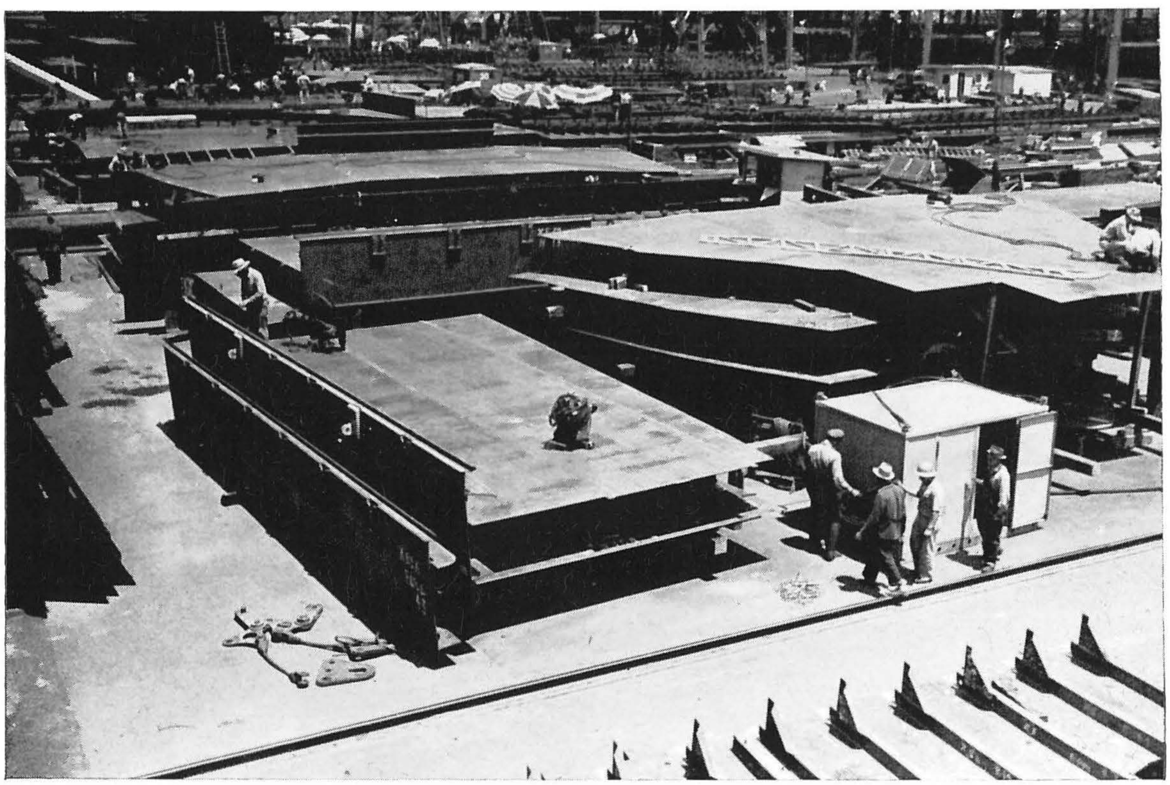
The sub-assembly is very simple. The plates are laid on horses, the crane places the frames in the proper location, and they are bolted in place.

Complete sets of finished plates and frames are stored in a rack at the assembly horses. A small crew assembles the frames as they are required and keeps the rack full.

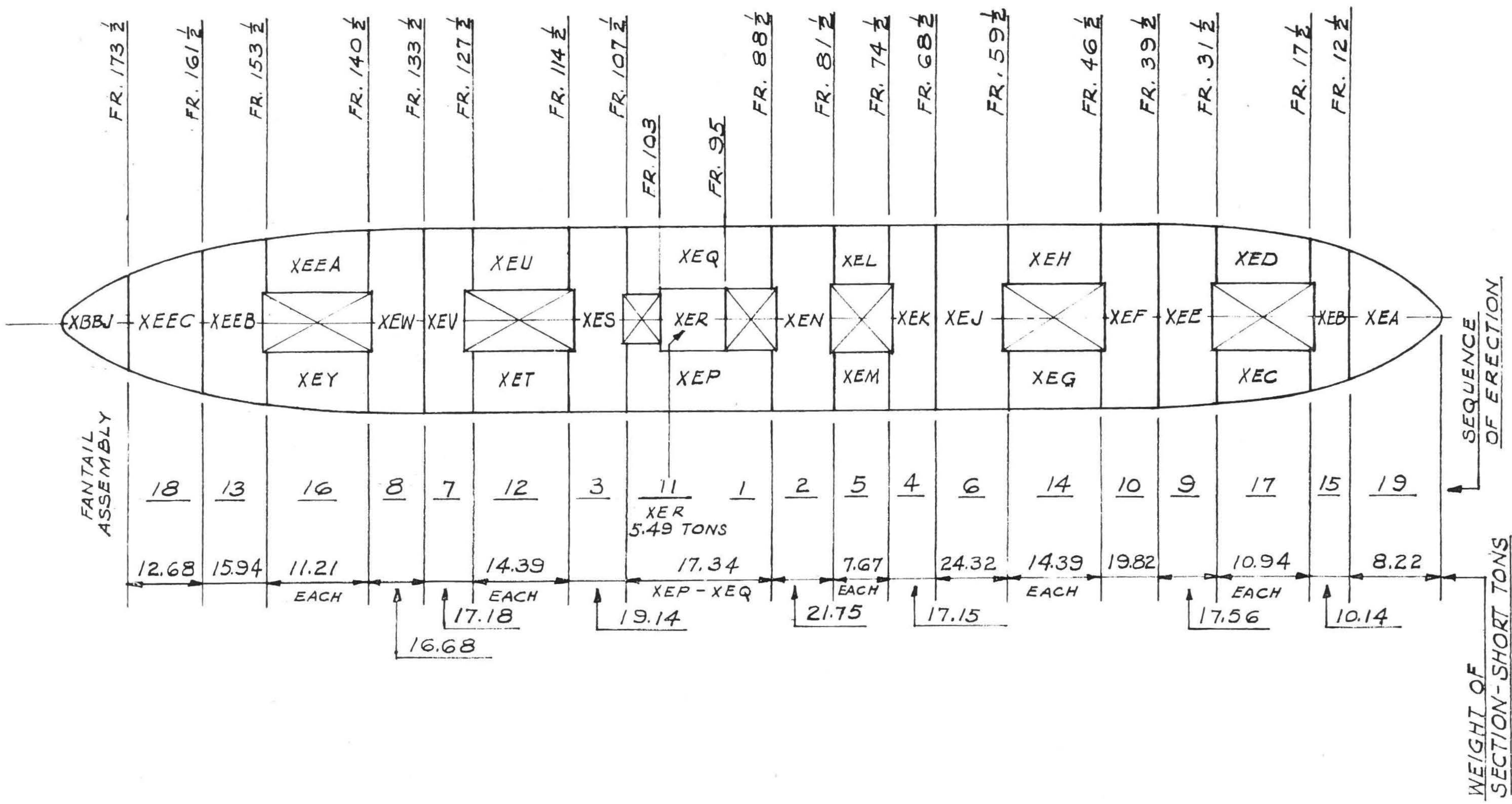
Sub-Assembly of Upper Deck Sections

The upper deck is divided into 25 sections in addition to the upper deck section included in the fan tail assembly. Each section is assembled on the skid in front of the way, complete with deck plate, deck beams, hatch end beams, longitudinal girders, and hoist foundation stiffeners. The sections at the forward and after ends of the hatch openings run transversely from shell to shell. The longitudinal sections are those outboard of the hatch openings and run from shell to longitudinal hatch girder the length of each hatch. The upper deck does not have the usual parabolic camber but a camber formed by three straight line chords across the longitudinal center section and inclined side sections. Thus there are longitudinal knuckles on the port and starboard sides between hatch openings.

The deck beams run transversely, intercostal of the longitudinal girders. The longitudinal girders reach from transverse bulkhead to hatch end beam in the transverse sections and from hatch end beams to hatch end beam in the longitudinal sections.



Upper Deck Sections Stored at Head of Ways.



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UPPER DECK ERECTION SECTIONS

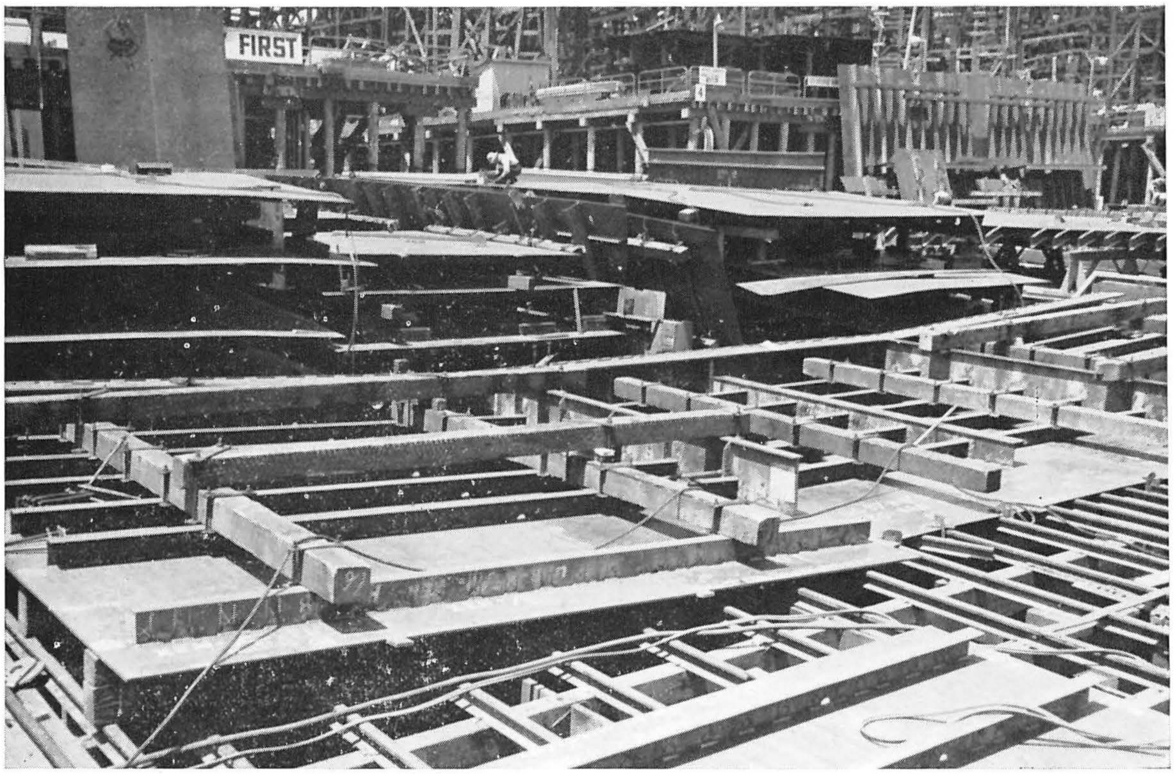
The plates come from the shop trimmed to the exact line of the seams and butts, and wild on the edges. They are laid on the skids upside down, fitted to a tight joint, and tacked. The layout man locates the beams and girders. When the layout is made for the deck beams, allowance is made for the slope in the cambered outboard section and for the change in sheer. Then all of the seams are unionmelt welded except the knuckle seams of the transverse sections which are temporarily left tacked. The center plates of the transverse sections are dogged down. The crane lifts each outboard end and pivots it about the tacked knuckle joint to form the cambered portion of the transverse upper deck sections. The shipwrights place tapered wooden wedges under the cambered plates, and the knuckle joint is unionmelt welded.

Setting and Welding Beams on Upper Deck Section.

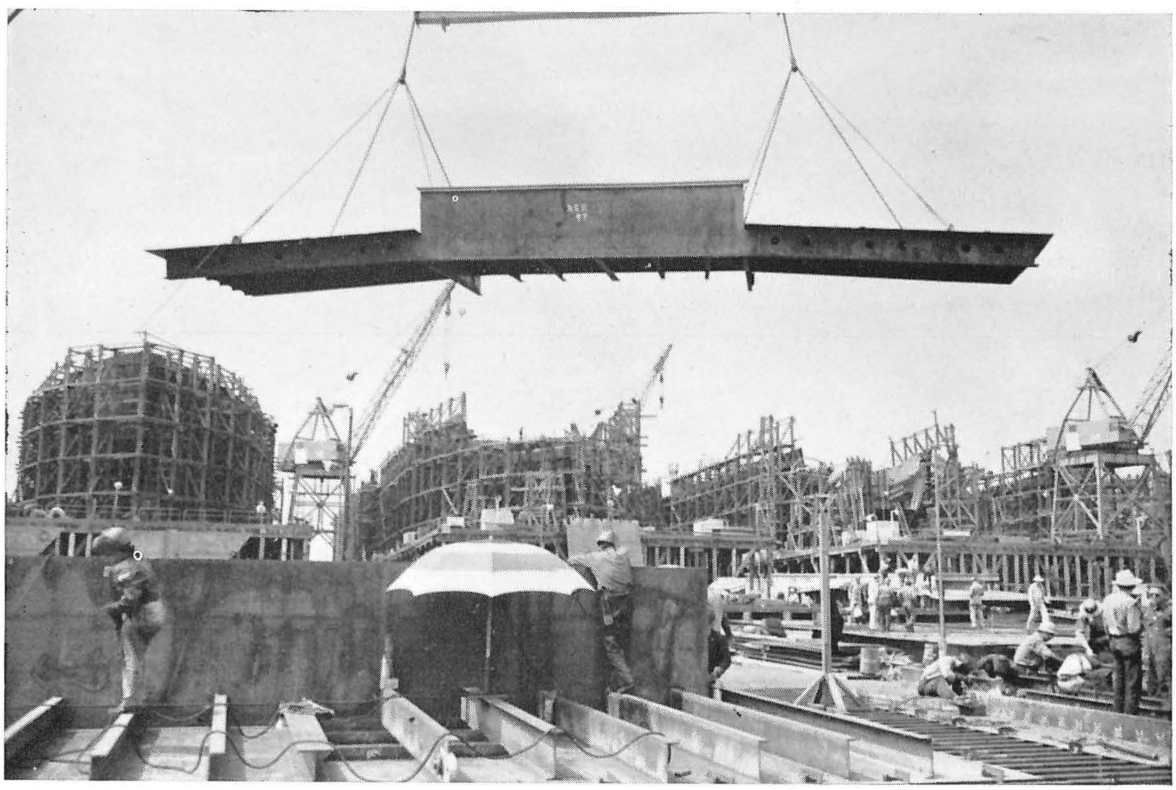
After unionmelt welding is completed, the deck beams are set in place, dogged tightly to the deck plate, and tacked. The beams are then set at the proper angle to compensate for the sheer of the deck and braced. The girders of the transverse sections are tacked in place, set at the proper camber, and braced.

Next the hatch end beam, or in the case of the longitudinal section the hatch side girder, is set and tacked. This comes from the shop in one piece, while the hatch end beam is shop pre-assembled in three pieces. Of these the center section is set first and then the two outboard sections are set and tacked. There are some advantages to welding the three pieces of the hatch end beams together before fitting them to the deck section as is done with the second deck hatch end beams; this is being tried now.

The center line girder, winch foundation stiffeners, and companion way stiffeners are set next and tacked. The section is now ready for timbering and then for production welding. After the welding is completed, the rolling and lifting devices are bolted on, the section is turned over, and it is set in the freeway between the skids and ways.



Upper Deck Section Timbered for Turning.

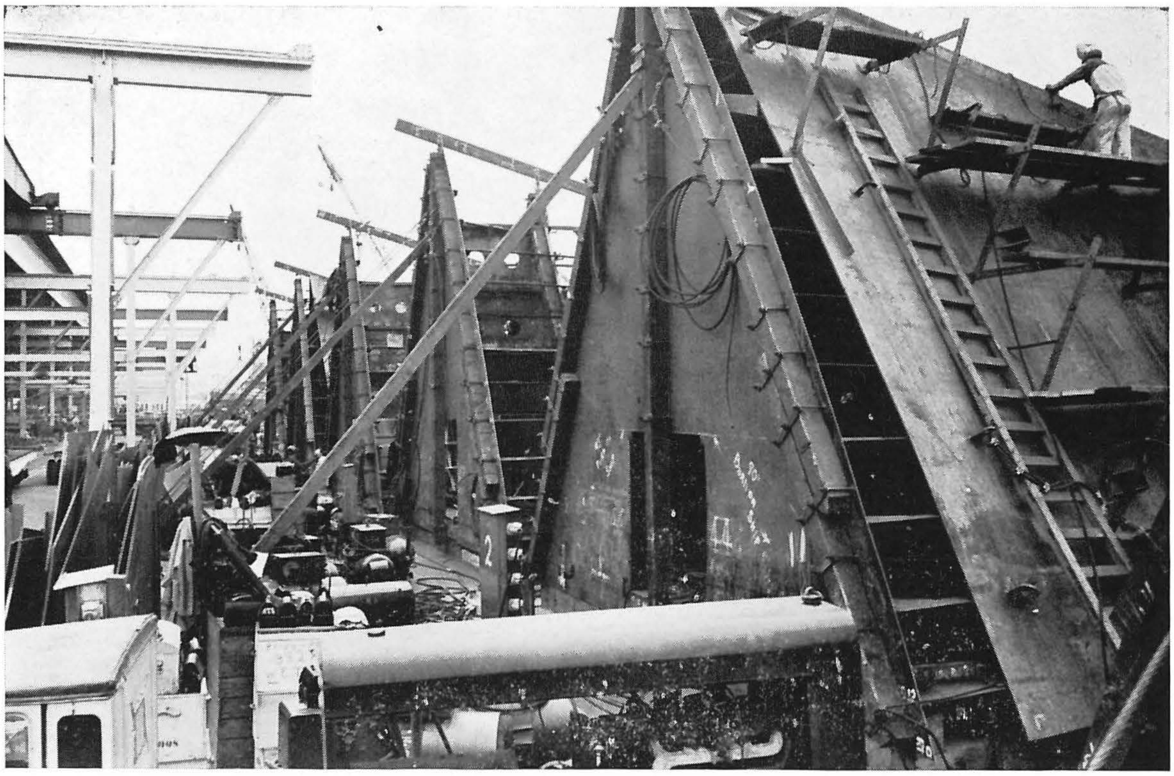


Transverse Section of Upper Deck Going to Hull.

The other side of the seams are unionmelt welded. Also the welding of the hatch end beams, of the butts of deck beams to the girders, and of the winch foundation stiffeners is completed. The layout men make the final layout, and the burners trim the deck plate to size with a radiagraph. All of the timbers are removed, eight lifting lugs are welded to the deck, and the section is ready to be placed in the hull.

Sub-Assembly of Forepeaks

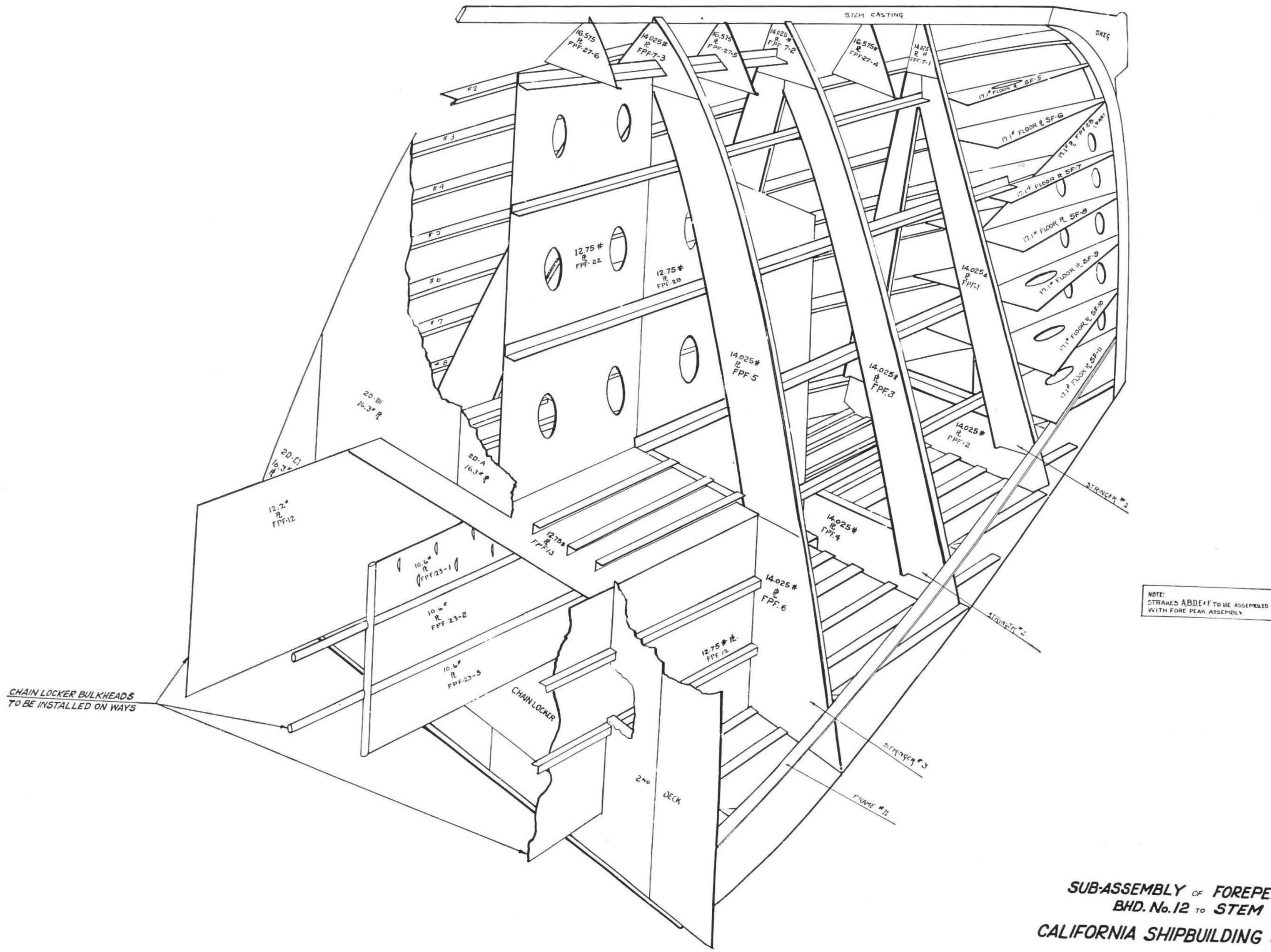
The forepeak from the second deck down and from bulkhead 12 forward is assembled in one piece on a special jig. This is the most complicated sub-assembly and requires the greatest care in fitting. Instead of building it in the normal upright position with the stem forward, it is built on its back with the stem at the top.



Forepeak Sub-Assemblies.

The bulkhead at frame 12, which is the base from which the assembly starts, is prepared ahead of time on a separate skid. Its preparation is simple and similar to that of any other bulkhead. The plates are laid down, tacked, and unionmelt welded. After the plates have been unionmelt welded but before the stiffeners are tacked to the bulkhead, the layout is made for the 6′ water line, the center line, the lines for stringers 1, 2, and 3, the vertical keel, the deep tank, the stiffeners, and the water stops. The water stops are cut as soon as they are laid out. Stiffeners are then set and welded. The bulkhead is timbered, turned over, laid out for trim, and burned. After it has been completed, the bulkhead is set on the forepeak jig with the stiffeners up, carefully leveled, and firmly wedged in position.

Then the jig is ready for the second deck section XCA. This is a simple deck section, and it can be built on any available skid area. After it has been unionmelt welded on the top, trimmed, and water stops cut, a ¾″ opening is cut 8′ long each way from the center on the forward side of the molded line of bulkhead 12. This opening fits over the plate at the top side of bulkhead 12 when the deck section is set on the jig. Timbers for bracing the section in the jig are placed on the top side of the deck



SUB-ASSEMBLY OF FOREPEAK
BHD. No. 12 TO STEM

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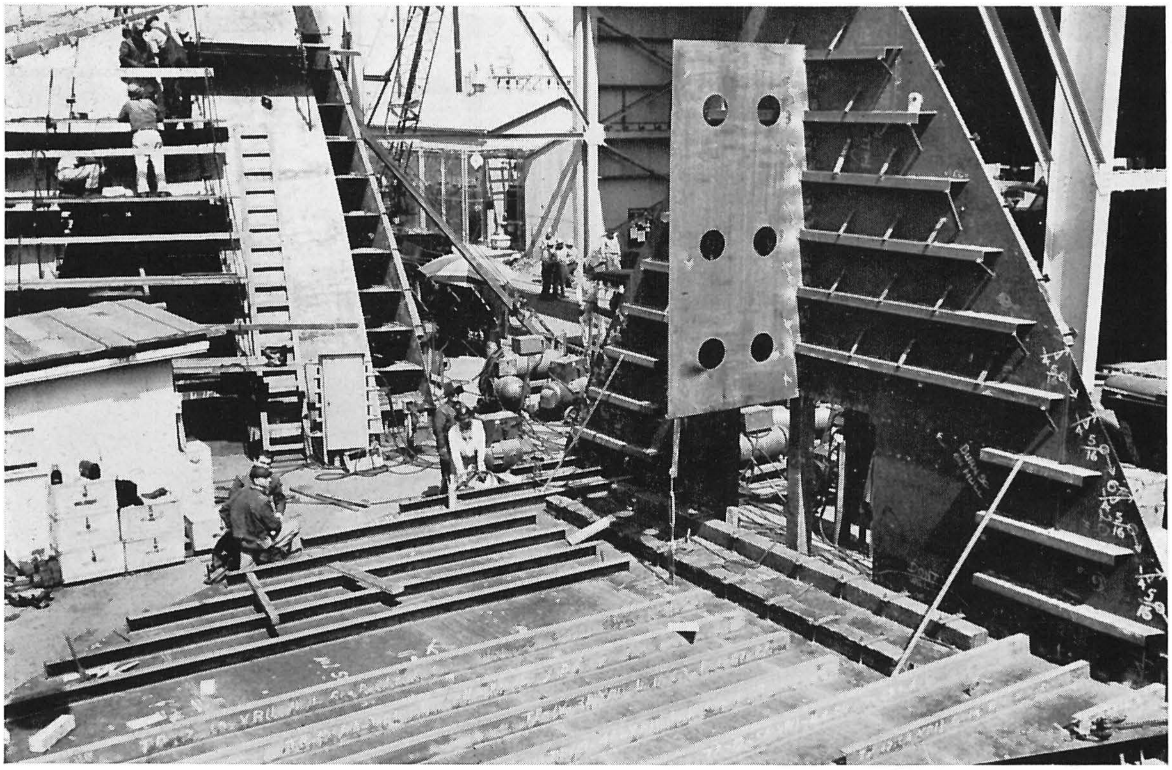
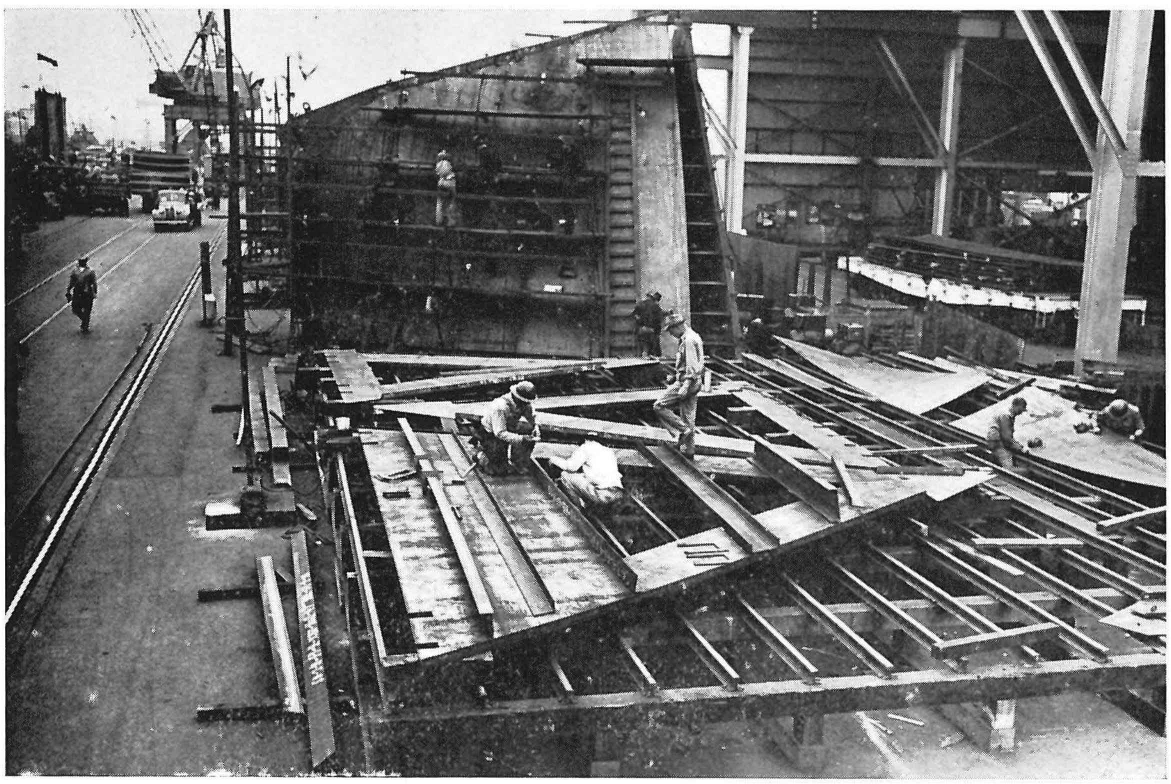
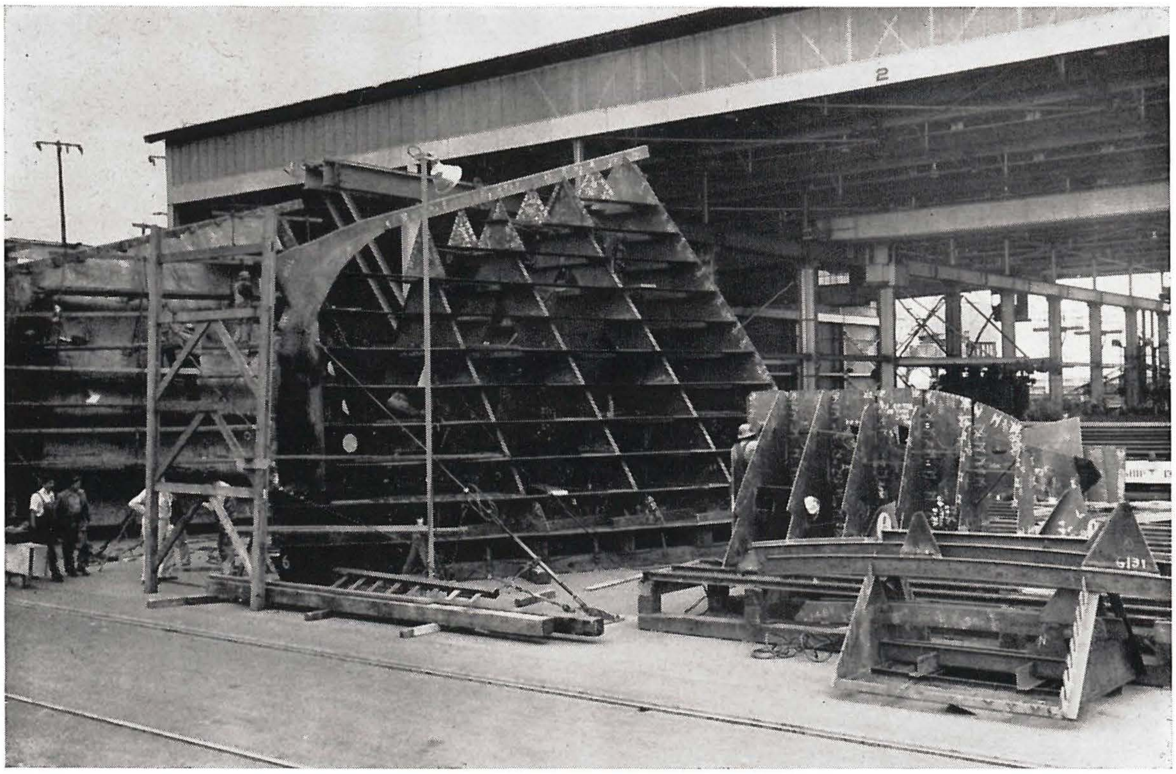


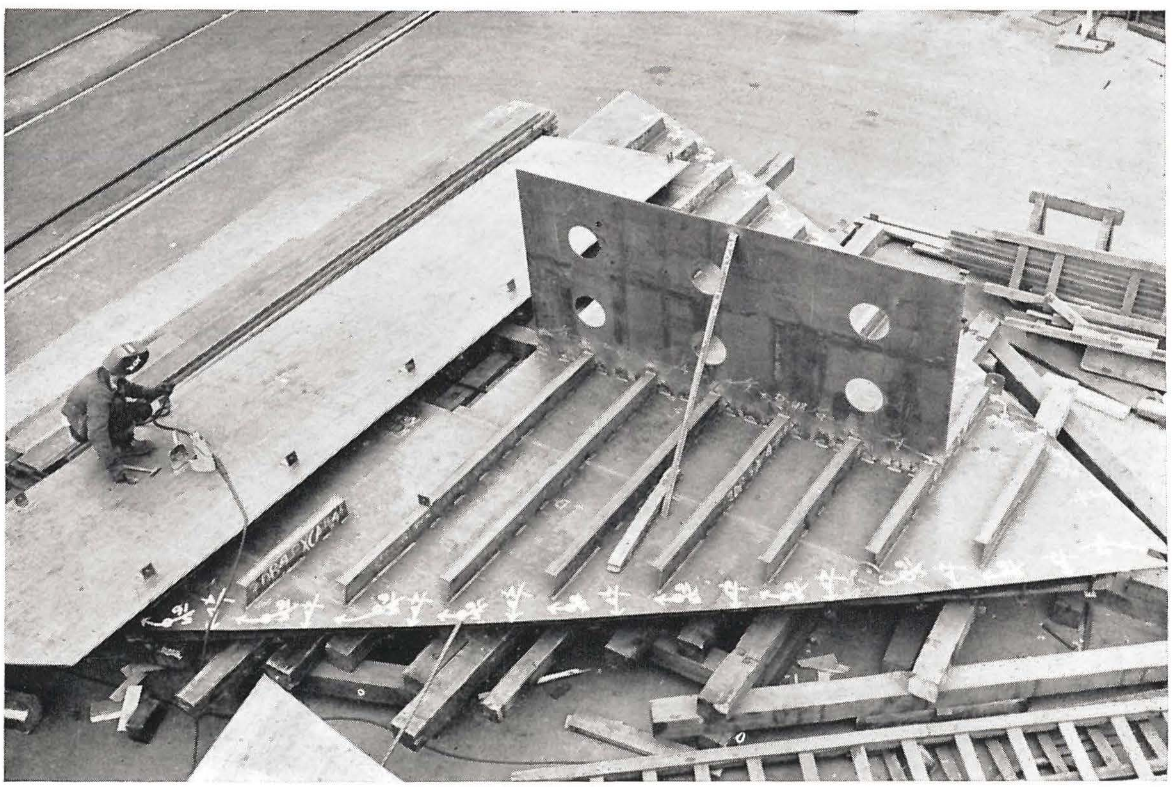
Bulkhead 12 on Jig and Second Deck in Place.



Assembling Stringers.



Assembling Floors and Intercostals.

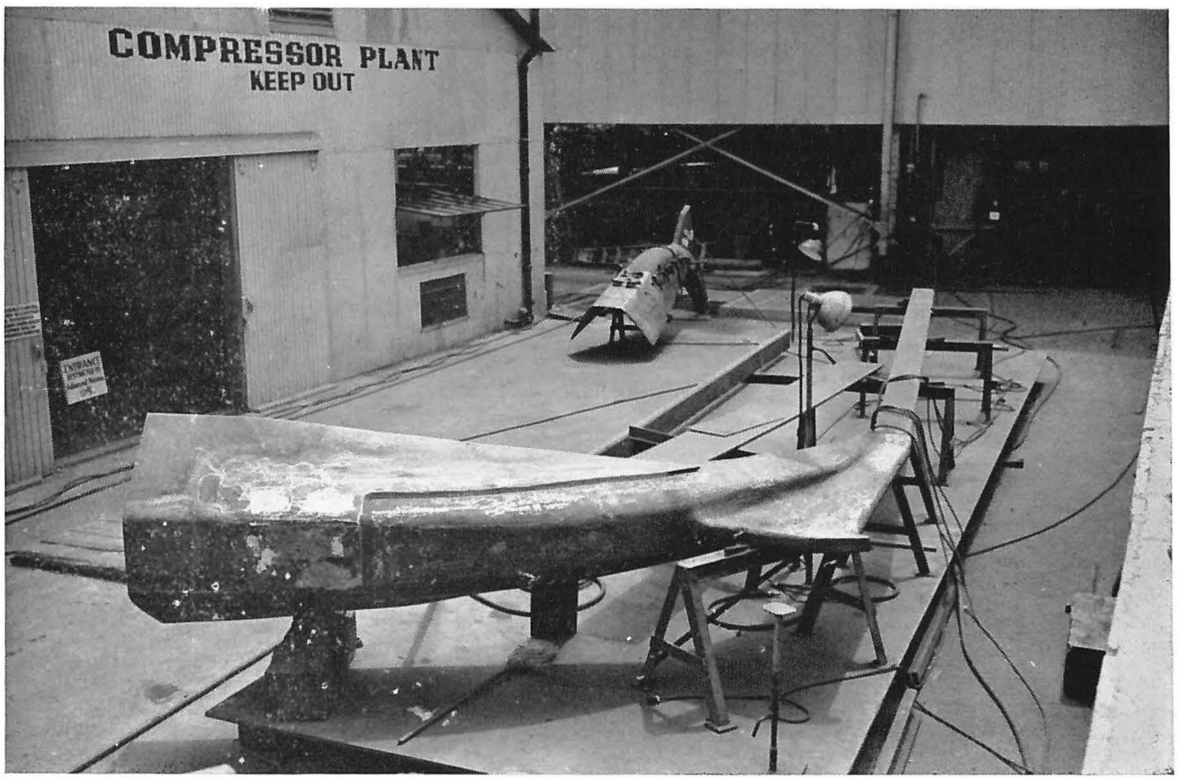


Assembling Second Deck.

Shell frames 11, 10, 9, 8, 7, and 6 are set in place. A 6′ water line is established on the floors. The frames are set from this water line and from the half breadths. Each frame has marked on it the location of the sight edge of the shell plates. A table has been prepared showing the "Height of Sight Edges." By using this table and measuring from the 6′ water line, the frame locations can be checked. The shell frame locations are important because the entire setting and matching of the shell plates depend on them.

The stem casting and the first section of flat keel are welded together on a separate skid, and then the stem bar is welded to the casting. The angle at the junction of the stem bar and the casting has been outlined on the skid. Each casting is set on horses, plumbed to the outline on the skid, welded together, and the assembly is ready to go to the jig.

At the jig a block square with a known chord is used to check the angle of the stem to the casting, to establish the frame lines on the casting and one water line on the stem. The water line on the stem is used as a match line for the template used to mark the other lines on the stem.

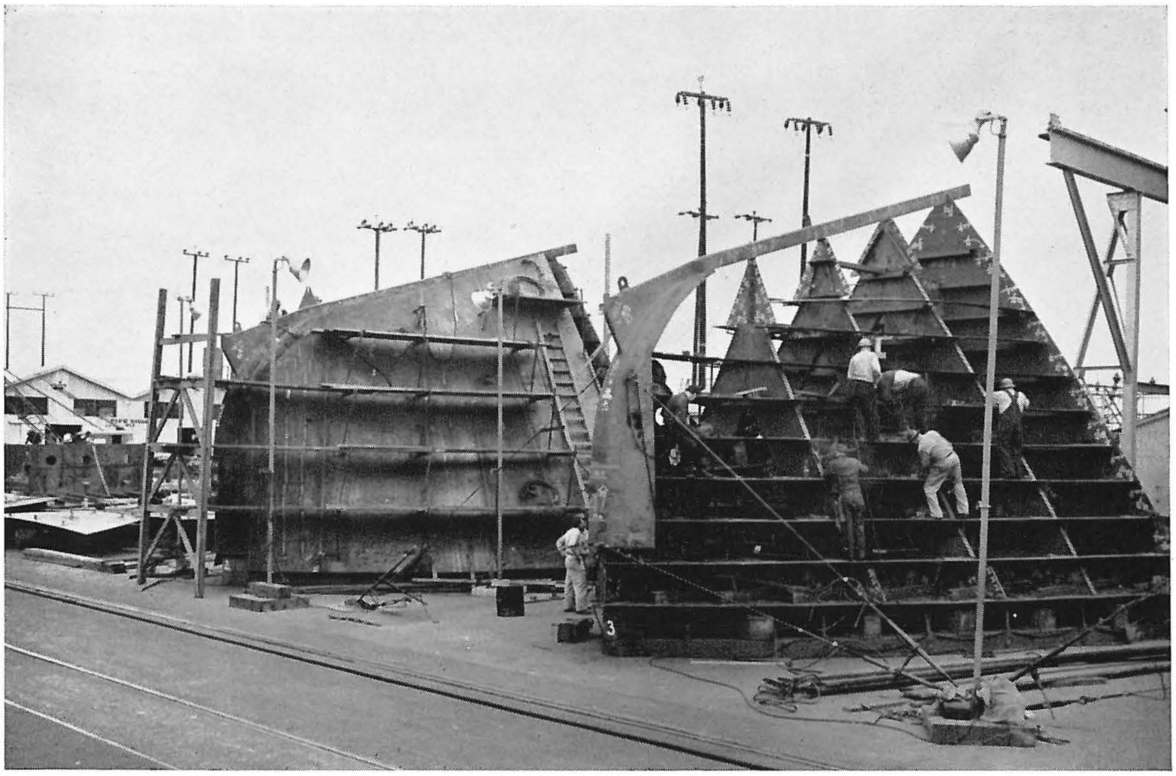


Stem Casting on Jig with Stem Bar and Flat Keel in Place.

Before the stem assembly is set on the jig, the water lines, molded lines, bearding line, lines for stringer plates, and the forward frames are located with a template and marked. The crane hangs the stem assembly on top of the framework of the forepeak. It is set to proper location, tacked to the stringers, and guyed with cables to hold it in position. The webs in the stem casting are checked with the floors to see that they fit together. Where a floor meets a web the floor is cut flush with the web, and a flat bar is welded over the butt.

The relative position of the forward end of flat keel plate FK-2 and the aft end of FK-1 is checked with reference to the molded line of bulkhead 12; also the lower aft sight edge is checked so that it will fit fairly to FK-2 which has been erected on the hull.

The production welding of the framework of the forepeak started when the stringers were set, and as soon as the casting is set and checked, it is welded to the floor section. Frames 5, 4, 3, and 2,



Welding Framework and Setting Frames.

can be set, tacked, and welded. They are left to the last so that the timber backing on the stringers can be removed. Frames 2, 3, and 4 are short, and the water lines on the stem bar can be used to set them. After the frames are all in place, the breast hook plates are set and the framework is completed.

Before any shell plates are placed, the framework is completely welded and inspected. There are two exceptions to the framework welding. The frames are only tacked to the second deck because the welding of the shell to the frame shrinks the frames and shell about 5/8"; and after the welding is completed, the end of the frames are cut loose from the second deck and a final weld is made with the second deck in the proper location. Also the stem bar is only tacked to the stringer plates and breast hooks until after the shell has been welded to the bar. Then the tacks are cut out if necessary, the plates straightened, and the final weld is made to the stem bar. The sides of the stringer plates and the breast hook plates must not be tacked to the shell until after the plates have been rewelded to the stem.

Shell plates B-1 and F-1 on each side are hung first because they extend from bulkhead 12 up to the stem bar and tie the whole assembly together. Also they provide a continuous strake line to which the shorter plates can be set. The shrinkage of 5/8" between the second deck and the keel is split between the joints of the plates so that after welding, the upper edge of F-1 will be on the line. B-1 is hung 1/4" and F-1 the full 5/8" above the designated sight edge height.

As each plate is hung it is tacked inside, and the final chain welding to the forward side of the frame is made so that the heavy plate will not break the tacks loose. Before plate A-1 is hung, the excess on FK-1 is trimmed by putting the A-1 template in place and scribing the FK-1 plate to it.

Plates A-1, D-1, E-1, and D-2, are hung on each side in that order and welded to the forward side of the frame. After the plates are hung, the fitters fair the seams by wedging them in or out, and 5" tack welds are made on the outside of the seam to hold the plates in place. 5" tack welds are used because short tacks would break out. The shell is trimmed neatly to the bearding line.

After all of the seams are tack welded, the production welding of the seams starts. One welder starts inside and welds 18" ahead of the outside welder. The reason for this procedure is that if the

inside shell weld is made first and the metal allowed to cool, the inside weld occasionally cracks when the heavy outside weld is made. The outside weld is kept 1/16″ below the surface, and a finishing bead is made in a final pass. If the plates are too close and the outside welder cannot get proper penetration, the seam is back-chipped after the insideweld is made.

The plates are all welded to each other, and then they are welded to the outside of the stem bar; also both sides of the stem must be welded simultaneously. The inside welding is done on the hull where the welding will be less vertical. By welding the stem last, it is not distorted by the shell welding.

The welding of the shell to the aft side of the frames would be overhead welding on the jig so it is left until the forepeak is on the hull; however, the overhead weld of the floors to the shell is rather inaccessible on the hull and it is welded on the jig. The bent clips TB-2 at the lower end of the stiffeners on each side of the centerline of bulkhead 12 are welded to the shell after the bulkhead has been welded to the shell and tested for watertightness. It saves difficult welding on the ways if these clips are production welded to the stiffeners on the assembly skid.

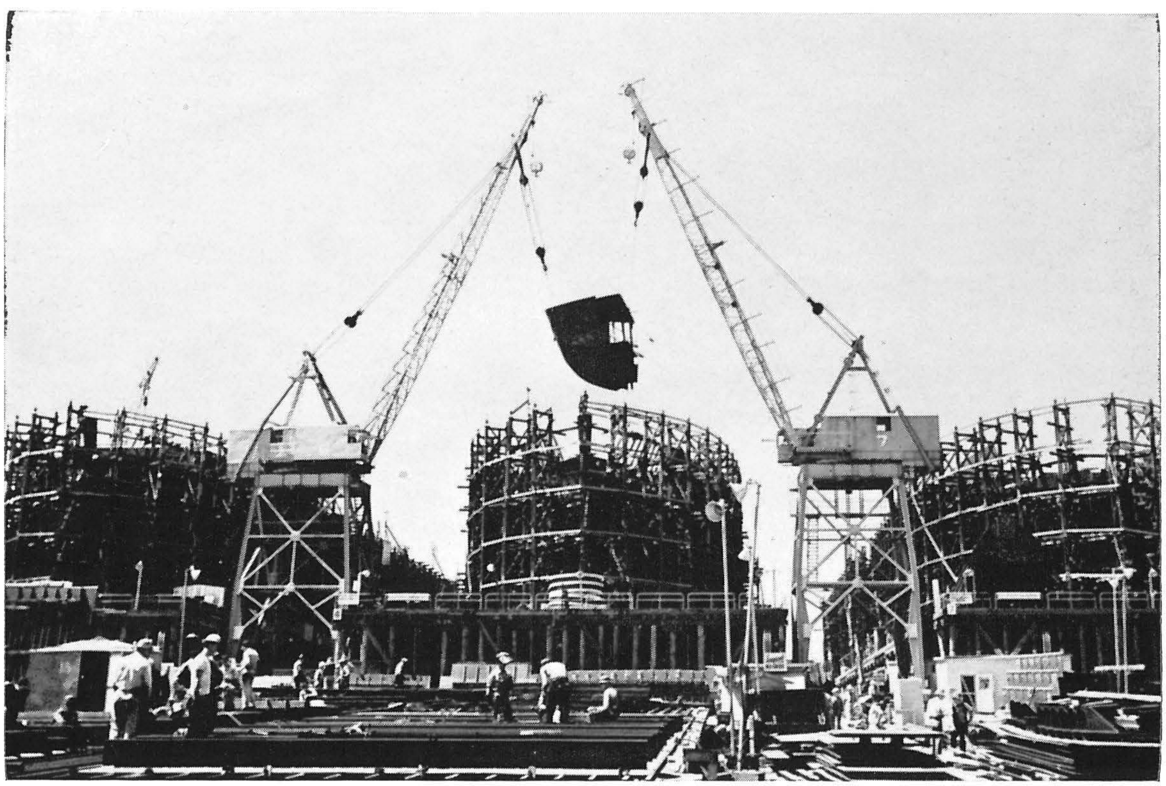
The continuous weld to the shell on the forward side of bulkhead 12 is made on the jig. Reverse polarity is used and the machine is stepped up to make a hot seal bead. The current is then cut down a bit and the bead completed with the reverse polarity.

The lifting pads are welded on, and the forepeak is ready to go to the hull.

Sub-Assembly of Fan Tail

The section of the after peak from frame 174 aft is assembled on the skids in one piece. Instead of being built on a transverse bulkhead as the forepeak is, the fan tail is assembled upside down. The cranes turn it over on the 174 frame side as they lift it off the jig and then turn it right side up when they take it to the hull.

The upper deck plates are assembled, welded, and trimmed on a separate flat skid. Lifting lugs are added and the crane sets the assembled upper deck plating on the jig. The center line and the molded



Cranes Carrying Fan Tail to Hull.

line of frame 174 are carefully lined to center line and frame line of the jig. There is considerable sheer to the upper deck at the fan tail, and the plates have to be dogged down securely. A turnbuckle is used to hold the aft end to the jig; and this turnbuckle also can be used to help fair the center line web plate, A. P. 27, to the aft edge of the second deck later.

Deck beams 174 to 182 are set and tacked. The beams are plumbed, which puts them at the proper angle with the deck, and they are then welded to the deck plating.

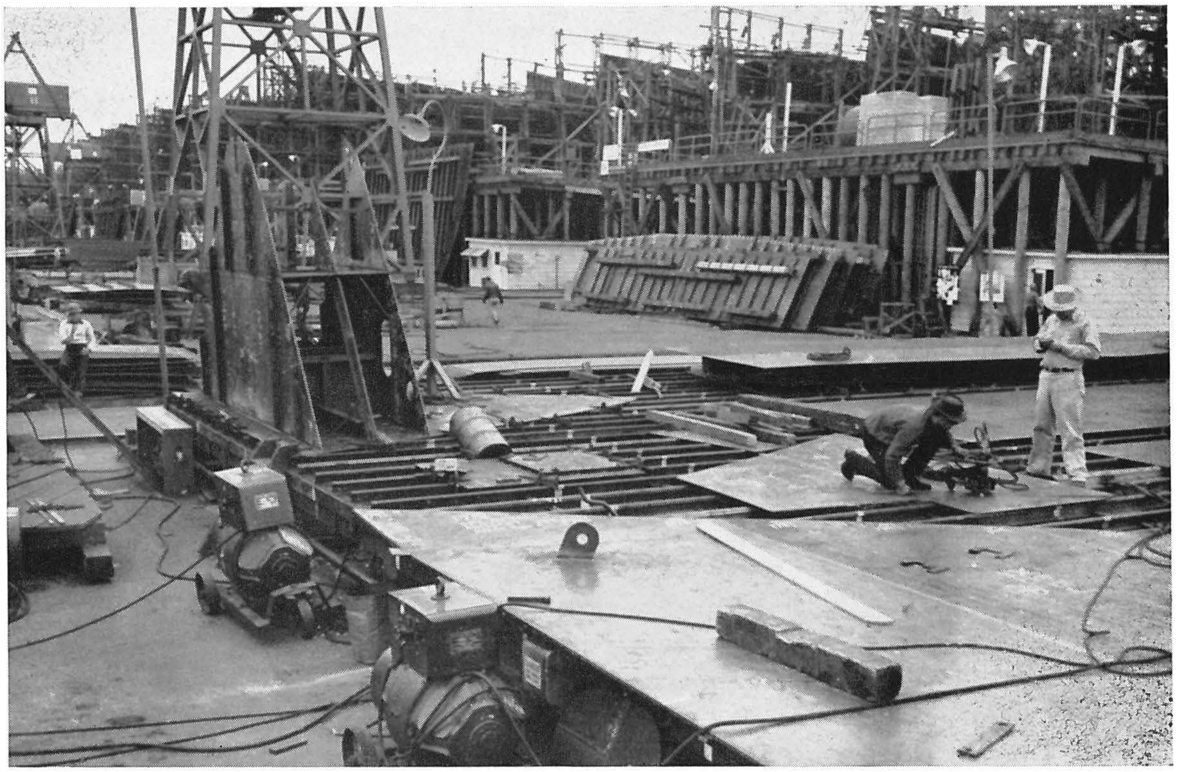
Upper Deck and Frames 174, 175, 176 in Place.

The center line and buttock points are established on the flanges of the deck beams. Buttock points are set 3″ short of the second deck half breadths at the corresponding frames. The port and starboard stanchions are 7′ from the center line on frame 174 and the center line stanchions on frames 176 and 178.

The center line web plate, the center line girder plate, and the stanchions on frames 174, 176, 178 are set and tacked. They are all welded, though the center line web plate is welded to the deck only and not to deck beams 180, 181, 182, or to the center line girder. This part is welded after any adjustments are made with the turnbuckle when the second deck is set.

In any convenient place near the jig, 'tween deck frames 177, 178, 179, 180, and 181 are set and tacked onto the port and starboard J-17 shell plates. The frames are faired to the curved frame line and to the 39′ water line established on the plates and frames in the shop. Steel templates tacked to J-17 hold the frames on the proper angle with the shell plate. The frame line is curved because the plate has a two way curve and the frames are at an angle with the shell.

The port and starboard J-17 plate and the frame assemblies are set on the upper deck, lining the frames to the molded line on the upper deck and the upper deck molded line on J-17 to the upper deck. The second deck ends of the frames are set by plumbing from the buttock points on the beams to the 3″ reference points on second deck end of frames. The frame brackets are tacked to the beams, and the shell is tacked to the upper deck. It is quite important that the shell and frames are not welded



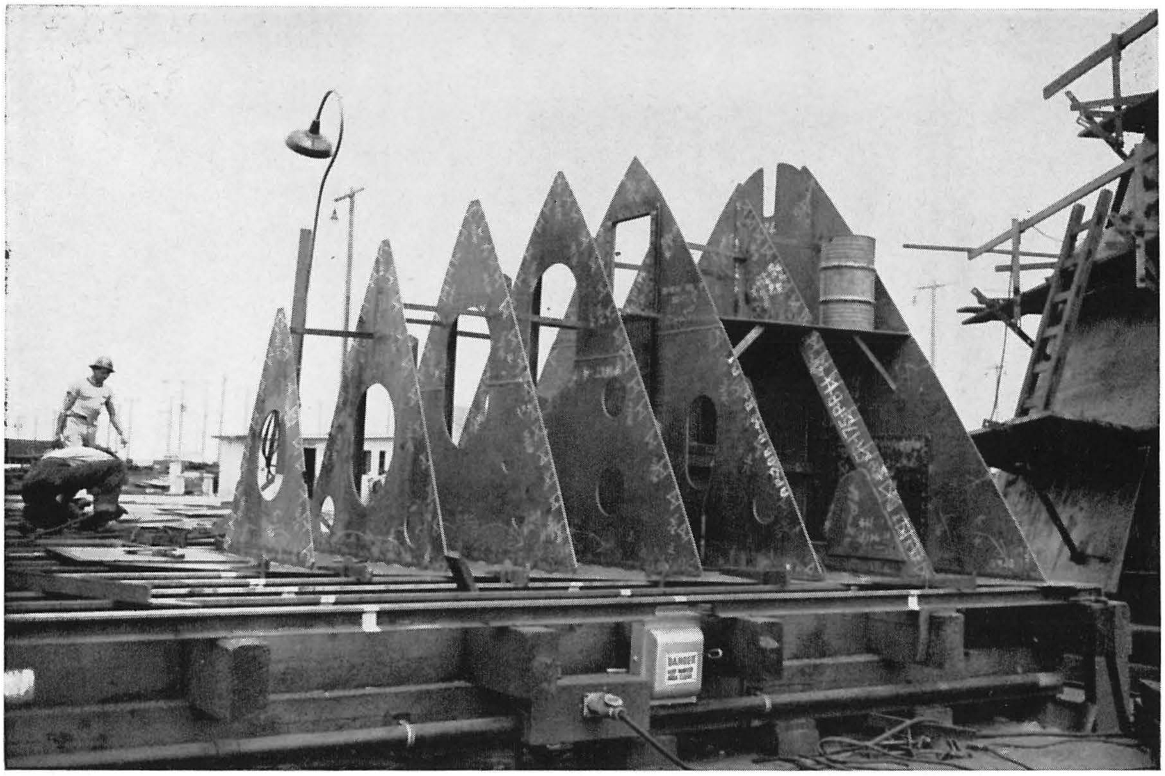
Fitting Upper Deck in Foreground and Second Deck in Rear.

either to the upper or lower decks until they are completely set and checked. Frames 174, 175, and 176, are set individually in the same manner.

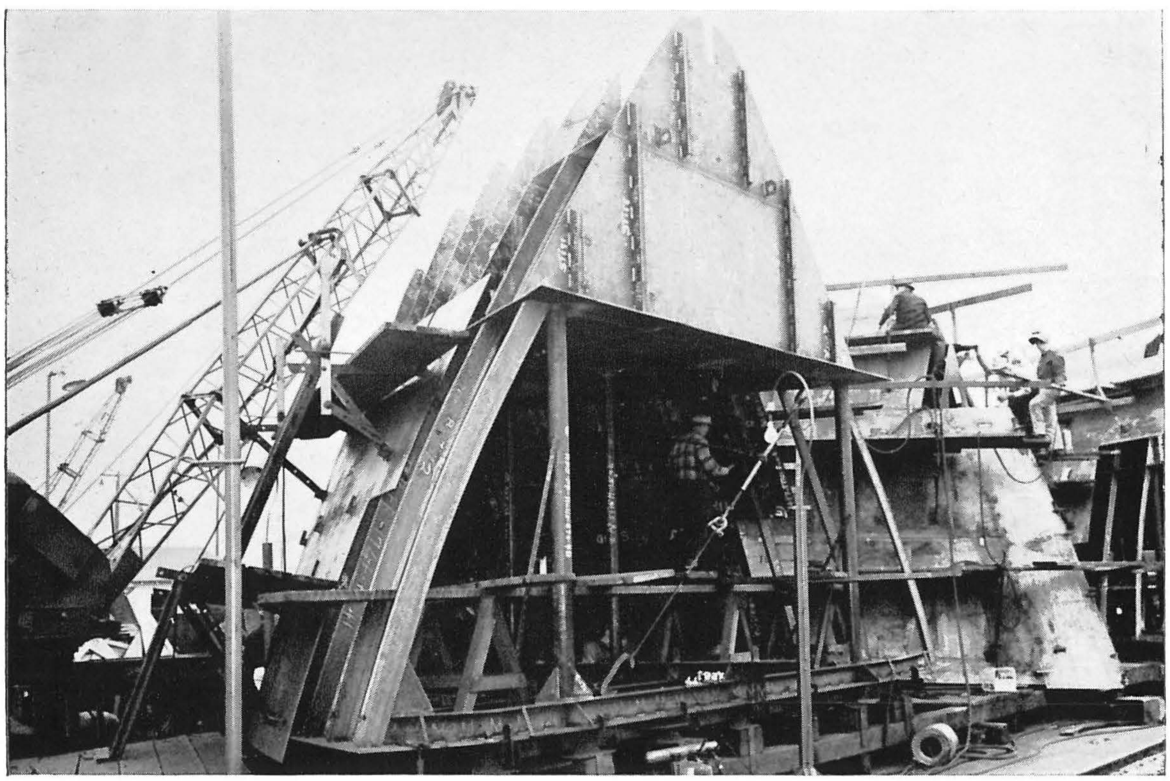
On a separate flat skid the second deck plates and the plates for floors 174, 176, 177, and 178 are laid down, faired, and tacked. The deck plates are unionmelt welded on one side and the floors on both sides. Then the layout is made and the floors are cut to size. Stiffeners are welded to floors 174, 176, 177, 178, and 179.

The doublers at the water tight covers are tacked and welded in position on the rudder trunk sides and the aft side of floor 176. The covers are tacked to the aft side of floor 174 port and starboard and to 176 so they will not be forgotten. Floor 174 is set on the second deck and tacked on the forward side. The rudder trunk plate, port and starboard, is set and tacked to the second deck. Floor 174 is then brought to its proper angle to second deck by pulling to the rudder trunk plate. Floors 176 to 180 are then set and tacked using 23½" spacer bars to carry through the proper angle to second deck. Then the following port and starboard pieces are set and tacked: second deck beams, bottoms of frame 175, rudder trunk stiffeners, AP-14-175's, and the flat bars from frames 175 to 177. The under stanchion gussets on the center line fore and aft at floors 176 and 178 are welded to the floors and deck.

After everything is assembled on the second deck and tacked in place, the welding starts. Lifting lugs are placed at the level of the rudder flat on the port and starboard side of the forward side of floor 174, and aft of floor 179 on the center line. After the unit is completely welded, it is lifted to working height. Frame lines and center lines are snapped on the top of the deck plating. Locating lugs are placed 7′ off the center line port and starboard on frame 174, on the starboard side of the center line between frames 180 and 181, and ½" to port at frames 180 and 181. These lugs are for centering the 174 frame stanchion and the center line web plate.



Second Deck and Floors Fitted and Ready to be Set on Assembly Jig.

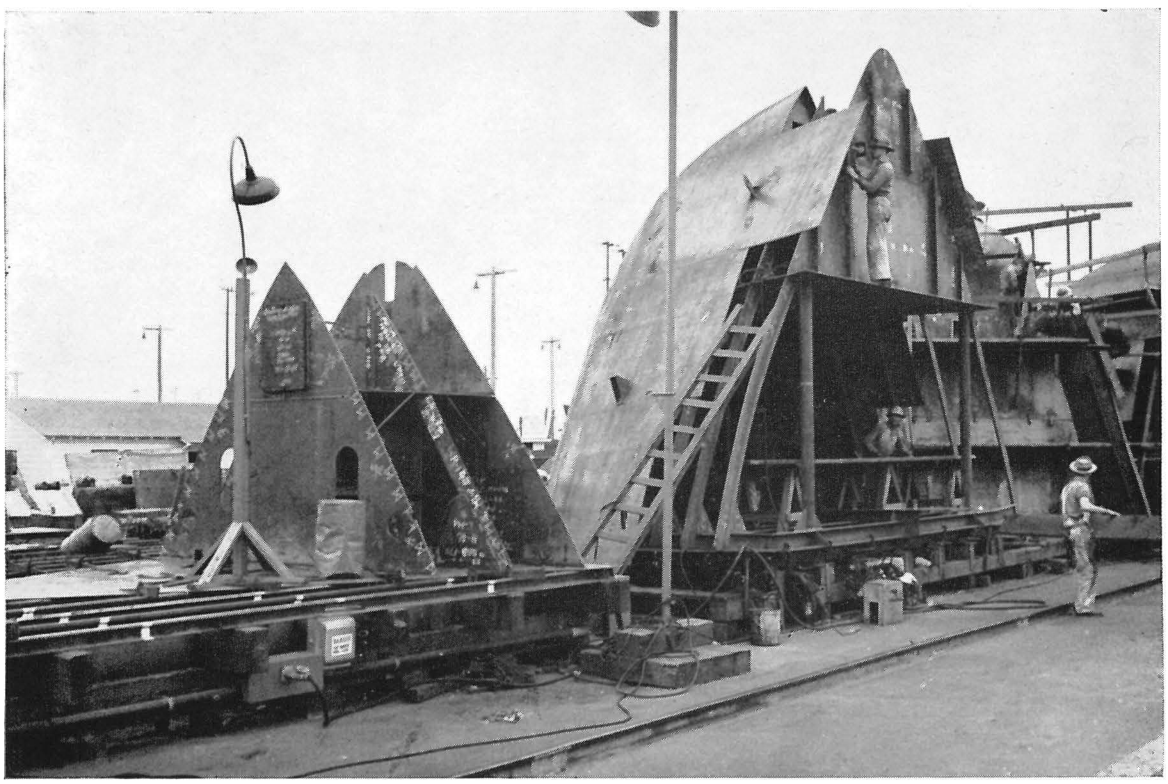


Second Deck in Place and Shell Erection Starting.

Then the second deck assembly is set on the jig and pulled to position with come-alongs and steam boat jacks. Plumbing is done from the second deck at the outboard edges of frame 174 and at the center line to set the second deck in correct position.

The center line of the second deck must check with the center line of the upper deck regardless of any possible variation in the half-breadth measurements. The aft end of the second deck and the aft end of the center line web plate are faired by adjusting the turnbuckle between the aft end of the upper deck and the jig which pulls the end of the center line web plate in or out on the center line. The second deck is tacked and then welded to the center line web plate and to the 174 stanchions. The frames are temporarily set to the molded line on the second deck with lugs. The center line web plate is welded to the upper deck beams, and all other welding of the framework is completed except the frames to the second deck.

Shell plates H-17 port and starboard are hung. The frames are faired to the frame lines on the plate and to the 36 foot water line. The second deck is faired to second deck molded line or shell. The seam between H-17 and J-17 is faired and tacked. Strongbacks are placed between the frames at the seam and half way to the second deck and the upper deck, making three strongbacks to each set of frames. The strongbacks hold shell in place and prevent its washboarding over the frames because of the continuous weld between frame and shell. The inboard side of the horizontal seam is welded aft to frame 180 and forward to frame 177. The frames are welded to the shell plates first with the intermittent weld on the aft side of the frames and then with the solid weld on the forward side of the frames.



Shell Erection Well Along and Another Second Deck Assembly Started.

The port stern plate is temporarily set. Then J-18 port is hung, continuing the line of the lower edge of H-17 along the bottom edge of J-18. J-18 is faired to J-17 and H-17, and the plate is pulled around the upper deck, the lower deck, and the stern plate. J-18 is tacked to the center line web plate after the center line web plate has been checked to be sure that it is straight and plumb. The stern plate was set temporarily to help with the setting of J-18. It is removed later so that frames 181 and 182 can be set and then replaced.

J-18 port is trimmed along a line 1" to starboard of the center line at the upper edge of J-18 and slightly tapered toward the center. The starboard J-18 shell plate and stern plate are hung in the same way, and J-18 starboard is trimmed to the center line of the port J-18. The starboard plate should not be tacked until it is completely faired and dogged into place. This will help prevent any buckling of the starboard J-18. The vertical seams on each side of the J-18 plates are not welded until frames 181 and 182 are set.

G-17 port is hung and tacked, and then the snipe is trimmed to the center line by a projection of the center line. The G plates are actually cut on a line curving ½" away from the center line to port and starboard aft, to reduce the center line hump at the G-17 and G-18 shell plates. This is also done at the G-18 and J-18 plates to smooth the curve to the J-18 plate. All of the shell plates are welded on the inside as erection proceeds, using strongbacks between frames to prevent buckling.

The port G-18 shell plate is hung and the aft end trimmed to the center line seam as was done with the G-17 plate. The port F-15 shell plate is hung next so that the welders can have free access and ventilation from the starboard side. Frame 181 is placed on the after end, and then G-18 is hung and faired to the center line. It is welded before F-15 starboard is set. F-15 is then set and welded.

The stern plates are removed, and frames 181 and 182 are set and tacked. The inboard side of the shell seams of J-18 and frames 181 and 182 are welded, and then the stern plates are replaced and welded. The outside of the J-18 seams are welded after the stern plates are set.

All shell seams are welded inside first; then they are back chipped and welded outside. Also the inside weld on all horizontal seams is kept 8" to 12" back from the butt to help in fairing the butt and preventing buckles. Seam J-17 and H-17 is not welded aft of frame 180 until J-18 is welded, except that J-17 to H-17 and J-17 to J-18 are welded where the frames cross, and the frames are cut out to fit over the weld. Care should be taken not to weld the center line seams of F-15, G-18, G-17, and J-18 below the second deck until the center line seam which determines the profile of the ship has been satisfactorily established.

Lifting and turning lugs are placed between the upper deck beams and frame 176 on the center of G-17 at frame 176, port and starboard, and at the aft edge of J-17 at the upper deck between frames 181 and 182. The fan tail is lifted off the jig and set on cribbing, with frame 174 down. Additional lifting lugs are welded to the upper deck and the second deck at frame 174, and the fan tail is ready to be set on the hull.

Sub-Assembly of Miscellaneous Superstructure Bulkheads

There are a large number of small bulkheads in the superstructure, all of which are assembled at the west skid along with the superstructure decks. Eventually these bulkheads will be assembled at the enlarged skid west of Way 1.

Their assembly is quite simple; the plates are laid down and pulled to place, and the seams are tacked. The layout is made, stiffeners set, and the seams and stiffeners are manually welded. The section is then turned over, additional layout made, and the manual welding completed.

At the present time these bulkheads go to the hull individually; however, as soon as room is available, it is proposed to assemble some of them into units on the skids before they go to the hull.

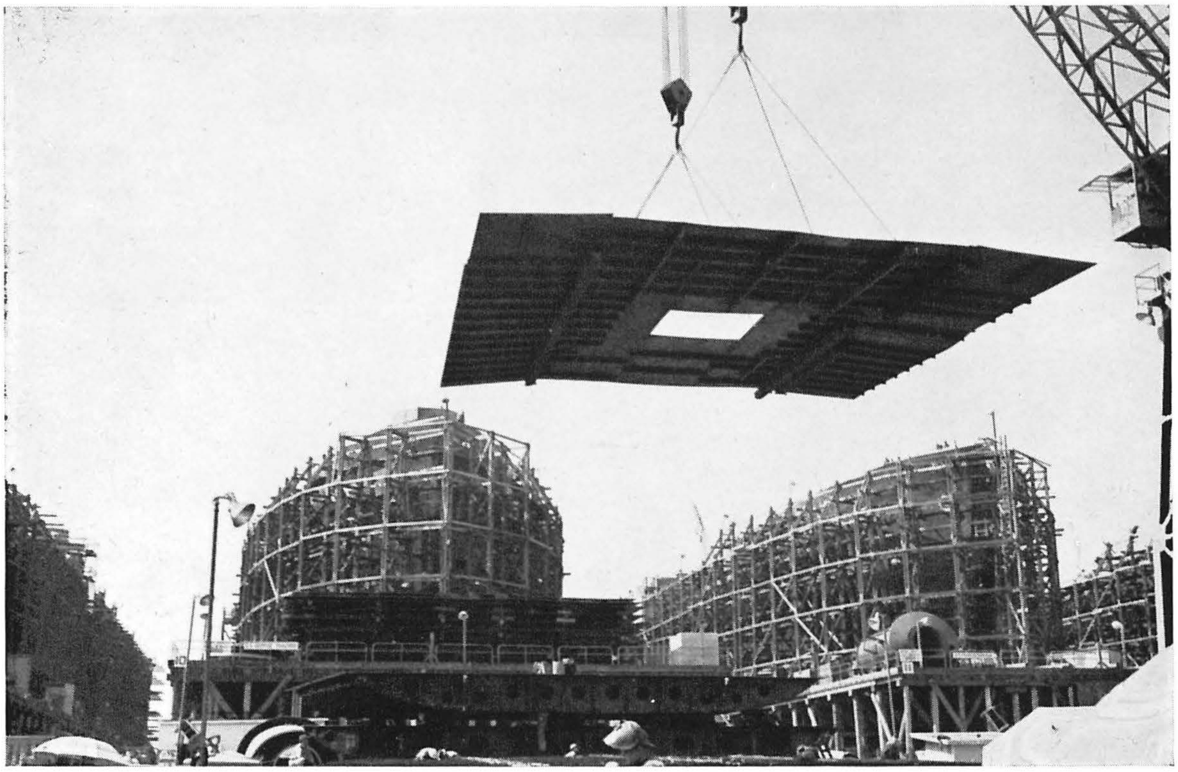
Small Bulkheads in Varying Stages of Assembly.

SUB-ASSEMBLY OF SUPERSTRUCTURE DECKS

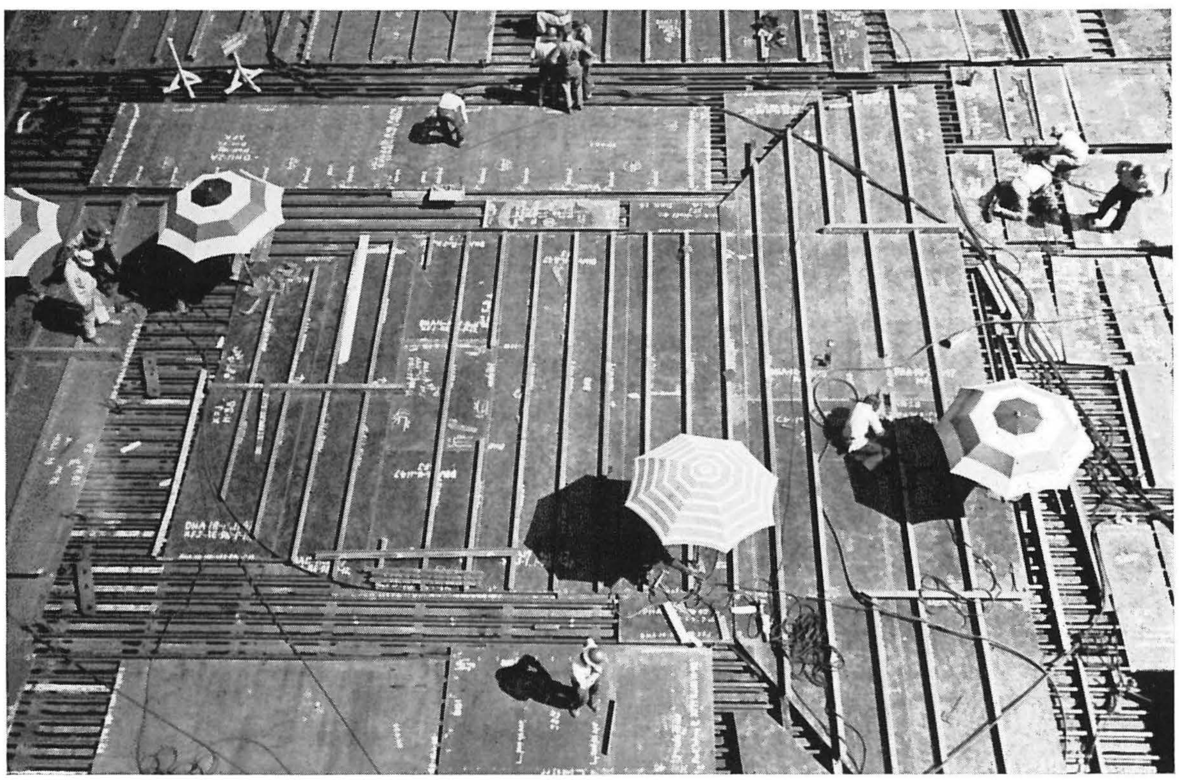
The superstructure decks which consist of the after deck house top, the midship boat deck, bridge deck, and bridge house top are assembled on the west assembly skid. The extension to the skid west of Way 1 is now available, and the boat decks are assembled there.

The boat deck which is the largest is assembled in two pieces and each of the other decks is assembled in one piece. The assembly of these decks is similar to that of the main decks except that the plates are thin and have more of a tendency to buckle unless the proper welding procedure is followed.

The plates are laid on the skids upside down in six sections—fore and aft on the outboard sides of the knuckle seams and the center line plates fore and aft of the machinery casing. The knuckle seam and the transverse seam are not tacked. The two longitudinal seams in each section are tacked and unionmelt welded.



Superstructure Deck Going to Hull.



After Deck House Top (Note Umbrellas to Protect Welders in Hot Sun.)

Boat Deck in Background, Bridge Deck in Foreground.

A parallel burn is made at the transverse seam between the fore and aft sections. But before the transverse seam is unionmelt welded, the knuckle seam is tacked. Then the transverse seam is unionmelt welded from the center outboard. The seams have now all been welded except for the knuckle seams which are tacked.

Layout men locate the deck beam and girder lines, and the fitters set and tack the deck beams in the proper positions. Then production welding starts on the beams from the center outward. After the beams have been welded, the crane lifts the outboard plates which pivot around the knuckle seam. The plates are blocked to the proper angle, and the knuckle seam is manually welded.

The longitudinal girders are set, tacked and welded. The timber stiffeners are placed and the section is ready to be turned.

The top side of the seams are unionmelt welded, the layout is made, the deck plate is trimmed, and the deck is ready to be set on the hull.

Sub-Assembly of Mast Houses

The three mast houses are assembled on the skid west of Way 1. The houses are practically complete when they go to the ways with the exception of the watertight doors which are put on at the outfitting dock.

The mast house top, which is in one piece, is laid down on the skids upside down. A layout man locates the mast holes, vent sleeves, boom steps, bulkheads, and the stiffeners.

The sides are in several pieces, and the plates are laid down on the skid alongside the top and assembled the same as ordinary bulkheads. The end plates and the rounded corners come in one piece from the shop.

Mast Houses Being Assembled Upside Down.

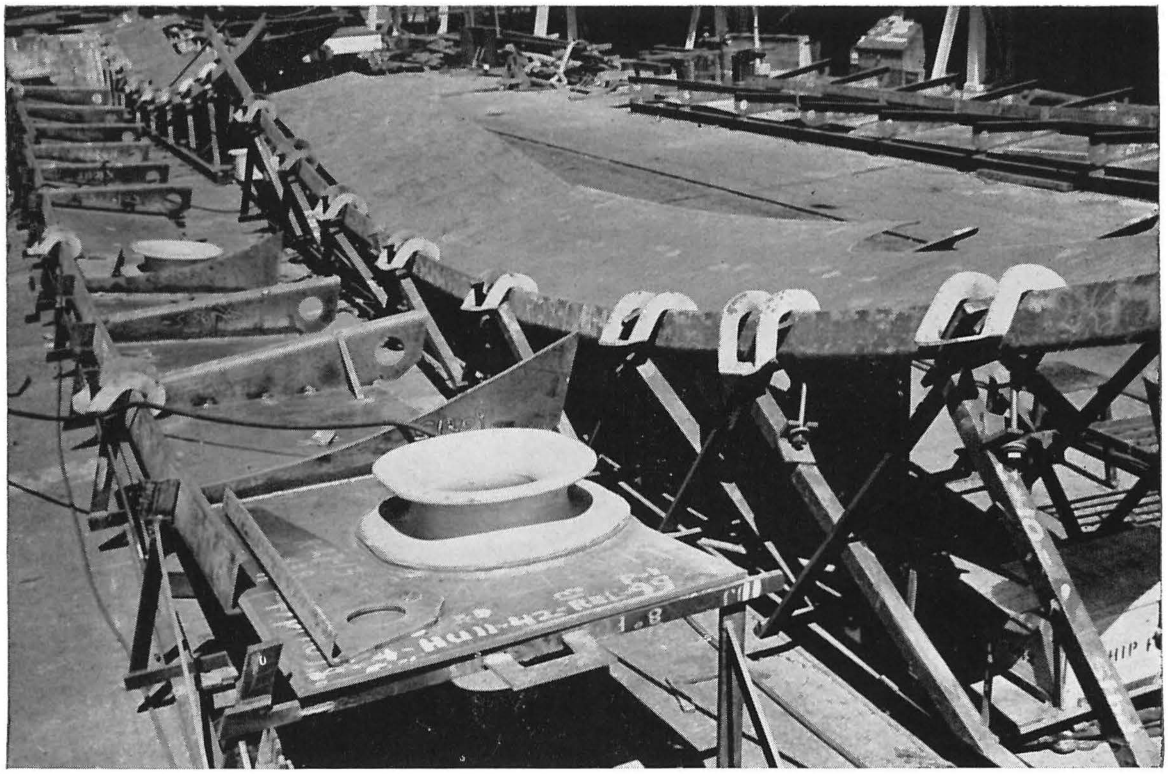
The boundary and sub-division bulkheads are set on the mast house top, and the whole house is assembled upside down on the skids. 1″ excess material is left on the bottom edge of all bulkheads to allow for scribing to the upper deck when the mast houses are assembled on the hull.

Sub-Assembly of Bulwarks

The bulwark rail, plate, and brackets are assembled on jigs and sent to the hull in sections. Each section is different and requires a separate jig. All the sections for one hull are laid down at one time.

Two or three rails, depending on the length, are set on the jig and pulled to line with saddles. The plate is set on the jig to the molded line of the J strake edge and tacked to the inside of the rail. The plates at the freeing ports and mooring pipes have been separately prepared and are placed with the rest of the plates. The rectangular freeing ports have been cut, but the half round reinforcement is added after the plate has been set in the bulwark jig. The mooring pipe castings are welded to the heavy plates beforehand.

After the plate and rail have been tacked together, the brackets are set on the plate to the proper angle with a template and tacked. Then starting in several places the bulwark is welded. The individual sections of rail are not welded together but are put on the jig together so that they will be in good alignment and will be easier to install on the hull.



Bulwarks in Jigs.

Mooring Pipe Castings Before Assembly.

Setting Half-round at Freeing Port.

The sections of bulwark are taken from the jig and dogged to the rails of a skid upside down. While the bulwark is upside down on the skid, the outside weld between the rail and the plate, the weld between the bracket and the underside of the rail, and the weld along the bottom of the half round at the freeing ports can be made in the flat position. The rough spots are chipped and ground down, and the section is ready for erection on the hull.

The freeing port half rounds that go on the outside of the hull at the roller chocks are not put on at the jig but are sent to the hull separately; also the nose plates and rails are separately fitted on the hull. Some of the bulwark brackets are flat pieces of steel with chafing pipes welded on the inboard edges. Arrangements are now being made to weld these pipes to the brackets at the training school instead of at the hull as is the present practice.

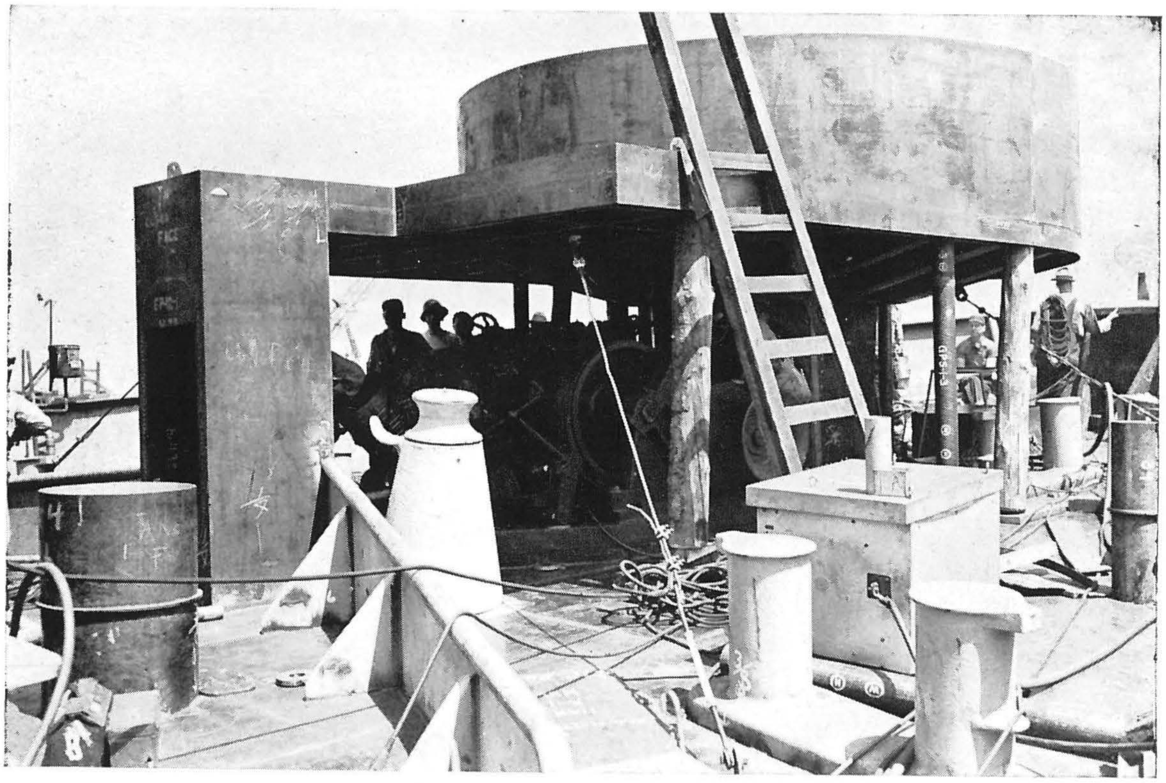
Sub-Assembly of Forward Gun Platform

The forward gun platform is assembled on the skids, complete with ammunition hoist trunk and platform support trunk. There used to be quite a bit of trouble with distortion, but this has been largely eliminated by improving the welding sequence and increased wedging to the skids.

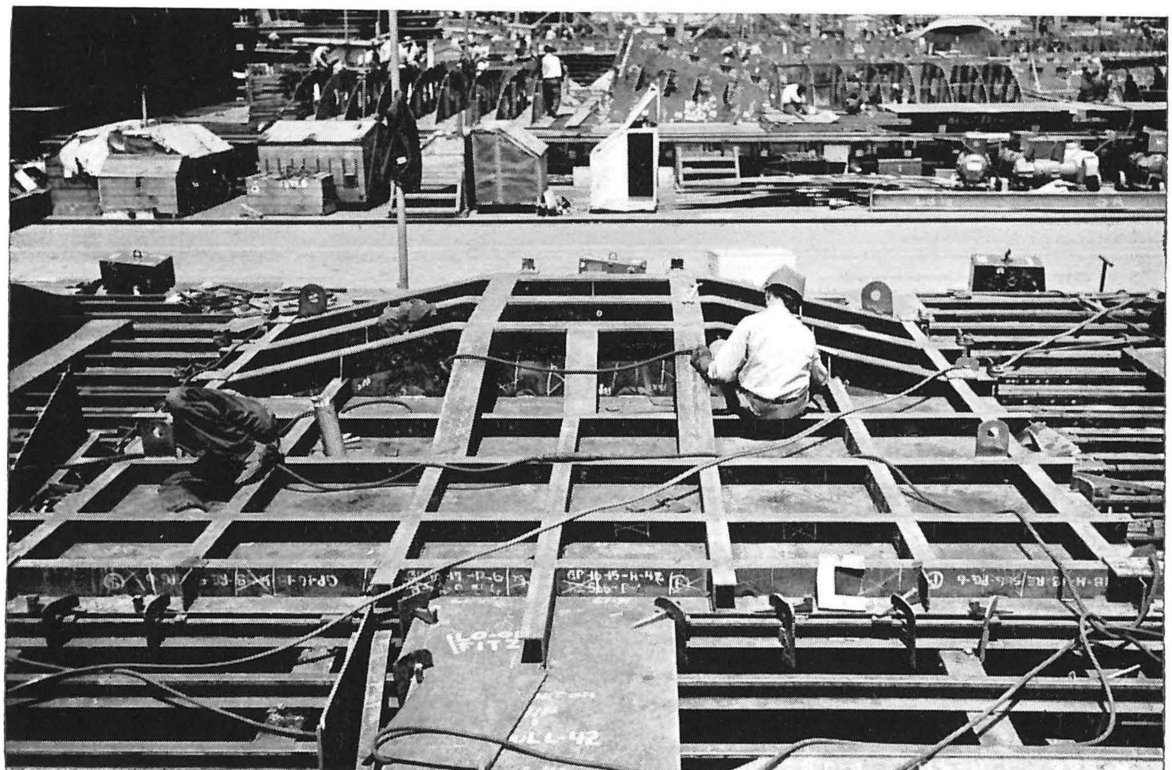
The platform plates are laid on the skids upside down. A grid of flat bars is tacked to the top of the rails to bring the lighter platform plates level with the heavier gun mount plate.

After the plates are pulled together, faired, and tacked, they are dogged down to the rails by 40 to 50 saddles tacked underneath the plate. The saddles are placed under the centers of the squares formed by the stiffeners wherever there is a tendency to distort. The seams are unionmelt welded, the layout is made, and the platform is trimmed to size.

The girders and stiffeners are set on the platform and tacked in place. Heavy tack welds are required at the inner ends of the girder flanges. The height of the girder flange from the platform plate is checked to see that it is the correct distance all of the way around so that the platform will



Forward Gun Platform on Hull.



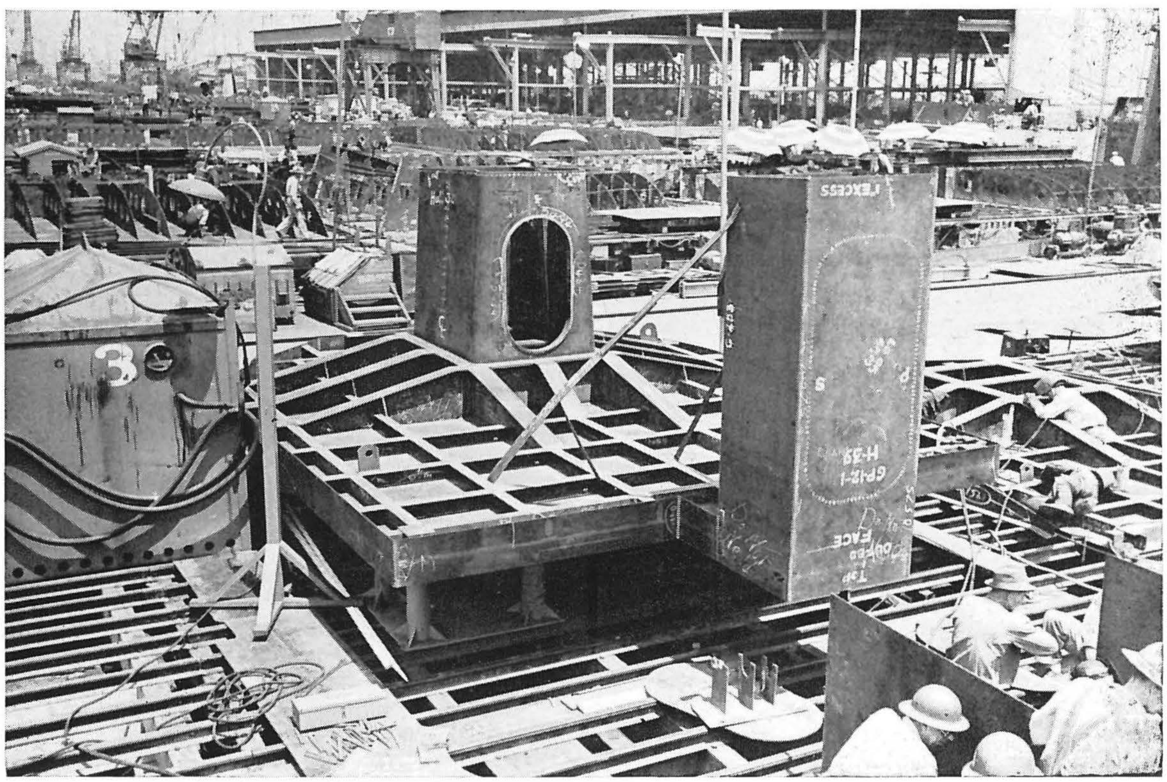
Welding Forward Gun Platform. Note Staggered Welding.

have a level support. The flanges of the girders under the gun mount plate are not pre-assembled with the web as is done with the tapered side girders. No welding is done until the complete assembly of girders and stiffeners has been thoroughly checked.

If the girders are rapidly welded to the deck from one end to the other, there will be a large amount of distortion. To avoid distortion, the welds are all stagger-welded and the welding is scattered. First a single pass bead is made to hold the flange plate to the web of the girders. The girders are then welded to the plating outward from the platform support trunk. The same welding sequence is followed on the stiffeners, welding from the middle towards the edges of the platform. The vertical welds at the inner ends of the tapered girders are made last.

After the girder and stiffener welding is completed, the platform is turned over onto a jig or timber cribbing, and the upper side of the platform is unionmelt welded. The weld around the thick gun mount plate is made by hand. Next the coaming around the edge of the platform is fitted and welded on top.

In order that the ammunition hoist trunk and the platform support trunk may be installed, the assembly is turned upside down again and the trunks set in place. Both of the trunks are welded together on the skids from shop prepared plates. An allowance of ½″ is made in the length of the support trunk and 1″ in the length of the ammunition trunk for scribing to the upper deck.



Forward Gun Platform Ready to go to the Hull.

ERECTION OF THE HULLS

The sub-assembly operations are only the means to the end of faster hull erection. The two operations must be coordinated carefully and smoothly in order that there will be no costly delays due to the improper flow of material.

The first requirement of a fast assembly program is a definite workable schedule controlling the delivery of the sub-assembled sections to the ways and the erection on the hull. Such a schedule is in use at this yard to control the flow of materials to the hull and the sequence of erection on the hull. An outline of this schedule is shown on the preceding page. Only the principal items that form the framework around which the schedule was made are shown. As the speed of erection has increased the schedule has been telescoped into fewer days, and the example shown indicates a schedule allowing 35 days between keel laying and launching.

The methods of hull assembly used on the ship ways utilize the best features of conventional shipbuilding covering shoring, blocking, staging, etc. The problem is affected only by the fact that the material in general arrives at the ways in large sub-assembled sections. Great care and constant checking are used to insure proper regulation of the ship so that as the large sections are put together the hull retains a fair shipshape form.

In this section covering hull erection are described the methods used to assemble and regulate the hulls on the ways.

Flat Keel

The minute the launched ship comes to a stop, work commences on the erection of the next hull. A crew of shipwrights start resetting the keel cribbing and preparing the new cap blocks. The midship section FK-9 of the flat keel is the first section to be placed, and the shipwrights concentrate on the midship keel blocks, with the smaller crews spreading the length of the hull. Other crews clean the grease off the ground ways, pile the bilge cribbing for removal by the crane, and remove the sides of the chain trough.

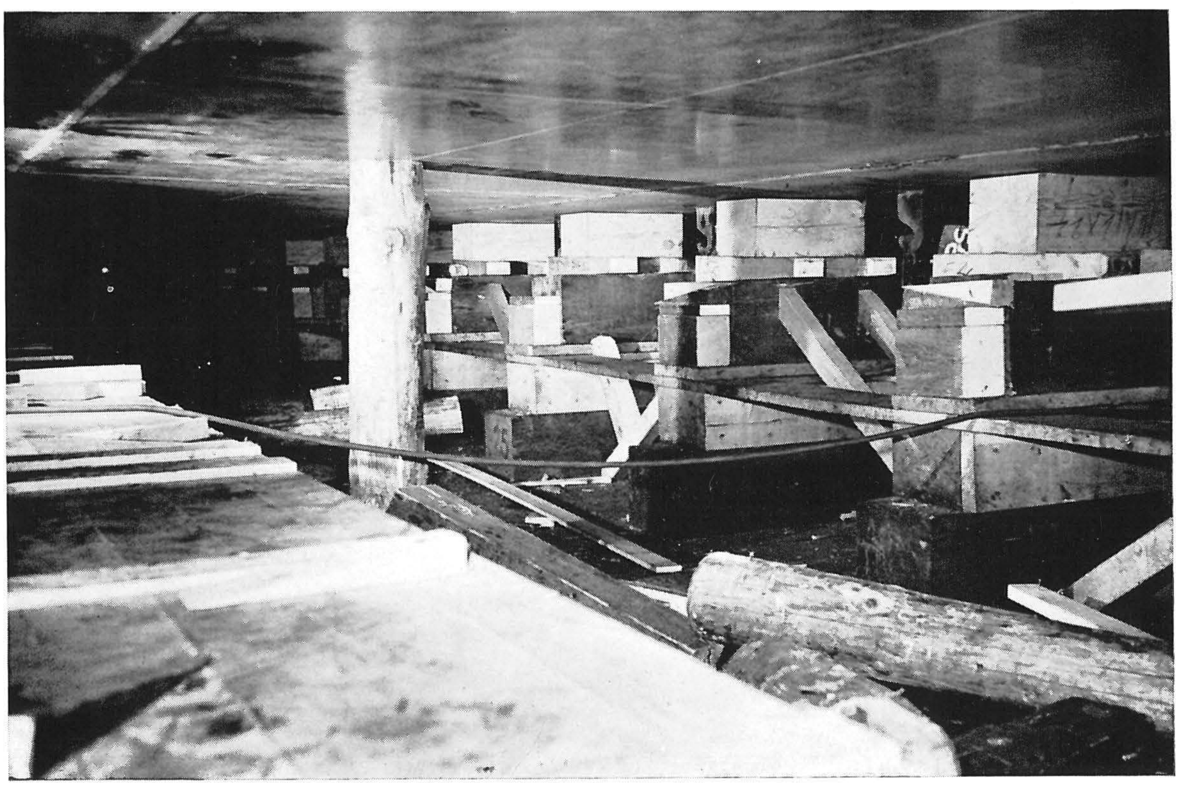
The engineers have set control points on the ways on the center line of the hull at 25′ intervals. These points are marked by steel plates imbedded in the ways. The midship line is marked on the ways by two control points 2′6″ off center, port and starboard. Instead of being on the fore and aft midpoint of the ways, they are aft a sufficient distance to allow for the declivity of the ways. The midship line on the flat keel is plumbed to the control point on the ship ways. Additional control points are set under the forepeak and afterpeak.

Setting Keel Blocks.

Eighty-two keel blocks support the keel. The blocks are on 5′ centers and are 54″ above the ways. Shipwrights set the keel cribbing and place the wedges on top. The cribbing is braced both ways with 4″ x 4″ lumber, and the wedges are toe-nailed to the cribbing. Any minor adjustment in the height of the cap blocks can be made later by a slight movement of the blocks fore or aft on the ways.

As soon as the wedges have been set, upright batter boards are placed on every fifth block. With a transit, the engineer sets the line of the bottom of the flat keel plate on the upright. The batter boards are completed by the shipwright, and a chalk line is stretched from batter board to batter board on each side of the keel blocks. The correct height of the cap blocks is marked from the chalk line, and then the blocks are taken to a portable saw and cut to the correct height. Each block is re-set on the wedges, adjusted to the height of the chalk line, and toe-nailed to the wedges.

Wedges on Top of Cribbing.



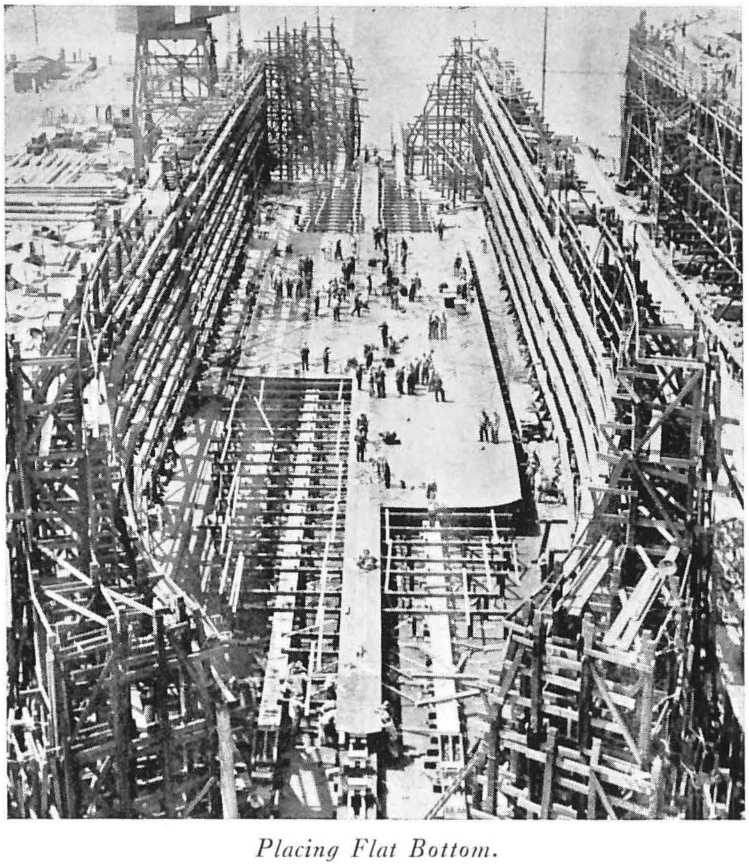
Keel Blocks Under Hull.

When the keel blocks between frames 84½ and 96½ have been completed, the crane lowers the first section of the flat keel into place. The center line and the midship line have been marked on the flat keel before it comes to the ways. The keel plate is carefully set on the midship line and center line by plumbing to the control points on the ways, and the engineers check the final location with a transit.

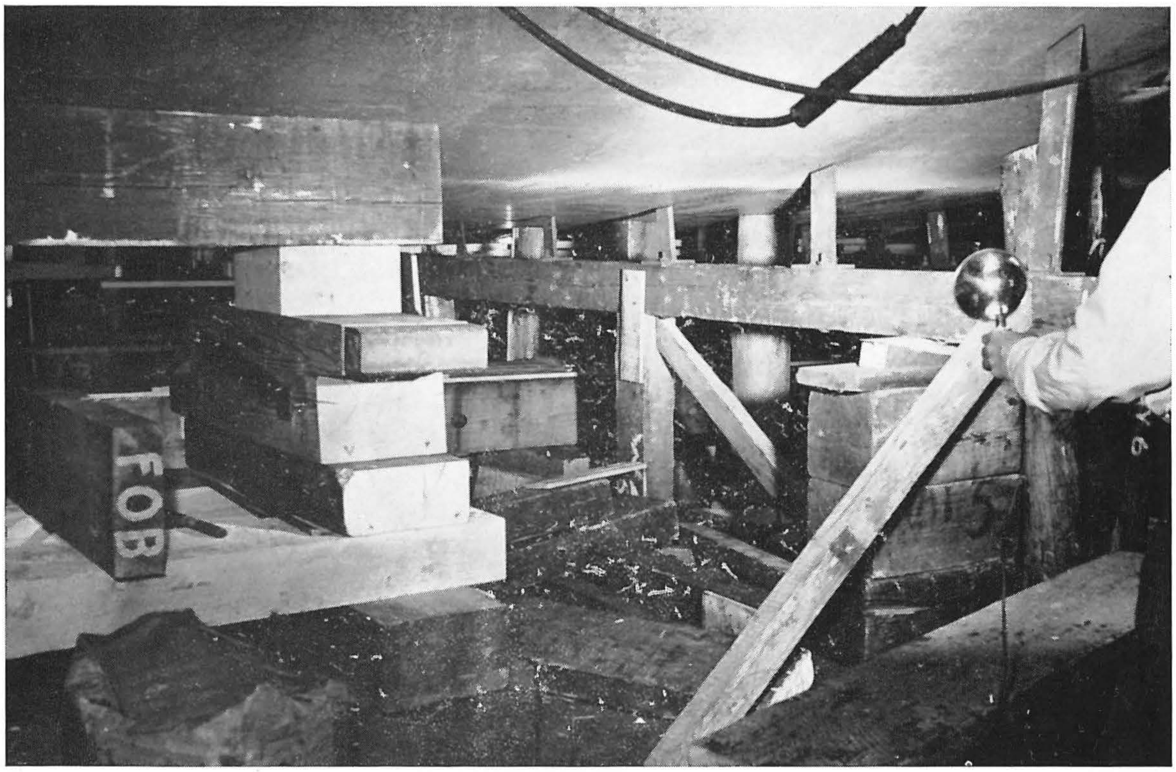
After the keel plate has been set, it is pulled tightly to the keel blocks by rods and turnbuckles between temporary clips welded to the bottom of the keel plate and permanent ring bolts on the surface of the ways. The remaining flat keel plates from No. 2 forward to No. 15 aft are similarly placed on the center line and checked by the engineers. As each plate is placed, the butt to the adjoining plate is fitted. Washers are tacked in the butt to maintain the ⅛″ clearance necessary to prevent the buckling of the plates when they are welded. After the flat keel plates have been set, the engineers check the center line. The butts are tacked as the plates are set, but the final weld is not made until the flat bottom sections are set.

Flat Bottom

The five flat bottom erection sections are temporarily supported on false cribbing made up of 6″ x 8″ timbers to which are fastened buttock irons. The tops of the buttock irons outline the bottom of the hull. Each erection section of the flat bottom has a port and starboard section. Erection section No. 1 between frames 68½ and 92½ on the port and starboard side of the flat keel is placed first. The transverse location is determined by the fitting to the flat keel seam, and the longitudinal location is determined by the midship line. As soon as the section has been properly set, the seam of the flat keel is fitted and tacked, allowing ⅛″ clearance as in the flat keel butts. After No. 1 port and starboard sections have been placed, No. 2 section is lowered by the crane into position aft of No. 1. The flat keel seam and the butt of No. 1 section are properly fitted and tacked, and the overall length is checked from the midship line. No. 3 flat bottom erection section is similarly placed forward of No. 1, and the



Placing Flat Bottom.



Buttock Irons and Bilge Cribbing in Place.

seams and butts are fitted and tacked. Sections No. 4 aft and No. 5 foreward have only two plates instead of the six (6) shell plates in the center of each of the port and starboard sections of erection sections 1, 2, and 3, but they are similarly placed.

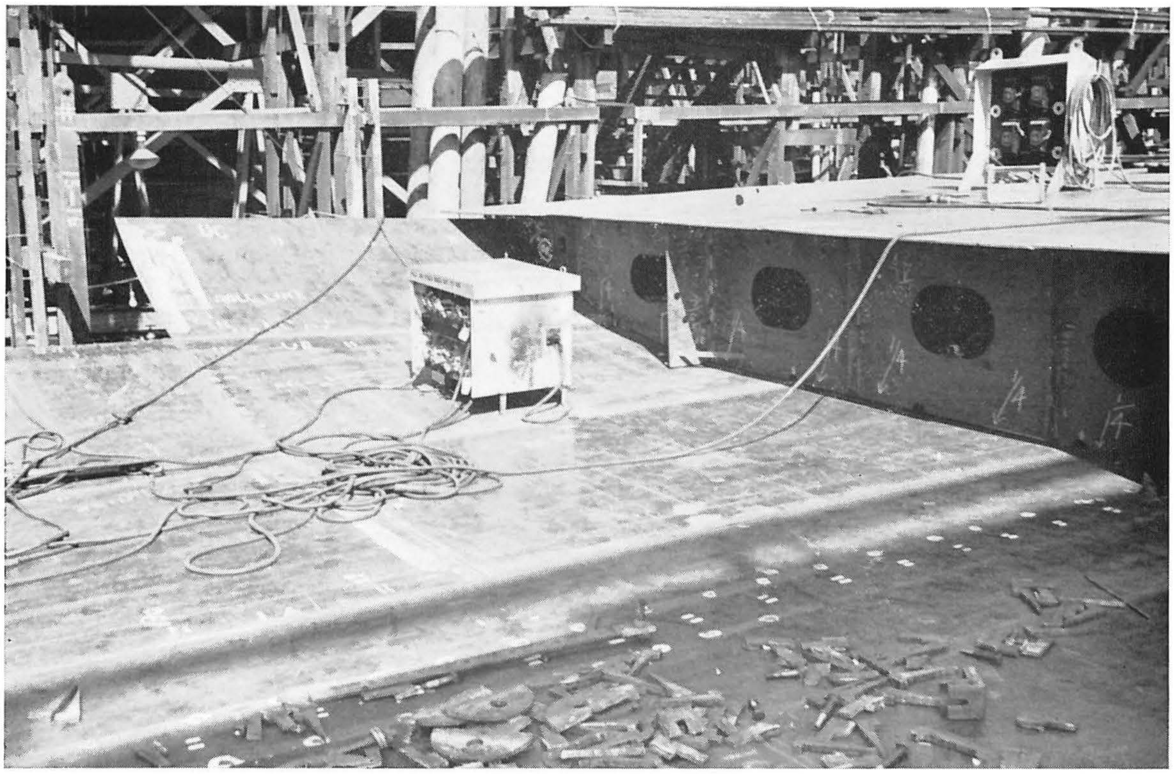
As soon as the first section of the flat bottom has been placed, the welders start the flat keel seams, working both ways from the midship line. Each keel is welded before the seam is welded across the end of the butt. If the ends of the butts are not free and the butt is welded, the plate will buckle. Similarly, the flat bottom butts are run part way out before the seam passes the butt. It is not necessary that these butts be completed before the seam is continued because the outer end of the butt is free.

The A, B, and C strakes fore and aft of the five erection sections are erected individually and supported on shores. After they have been pulled into place they are tacked. The welders continue fore and aft and pick up the individual plates as they come to them. Shell plates B-2 and C-2 are not welded until after the double bottom has been placed, because otherwise it is hard to pull them to the proper shape.

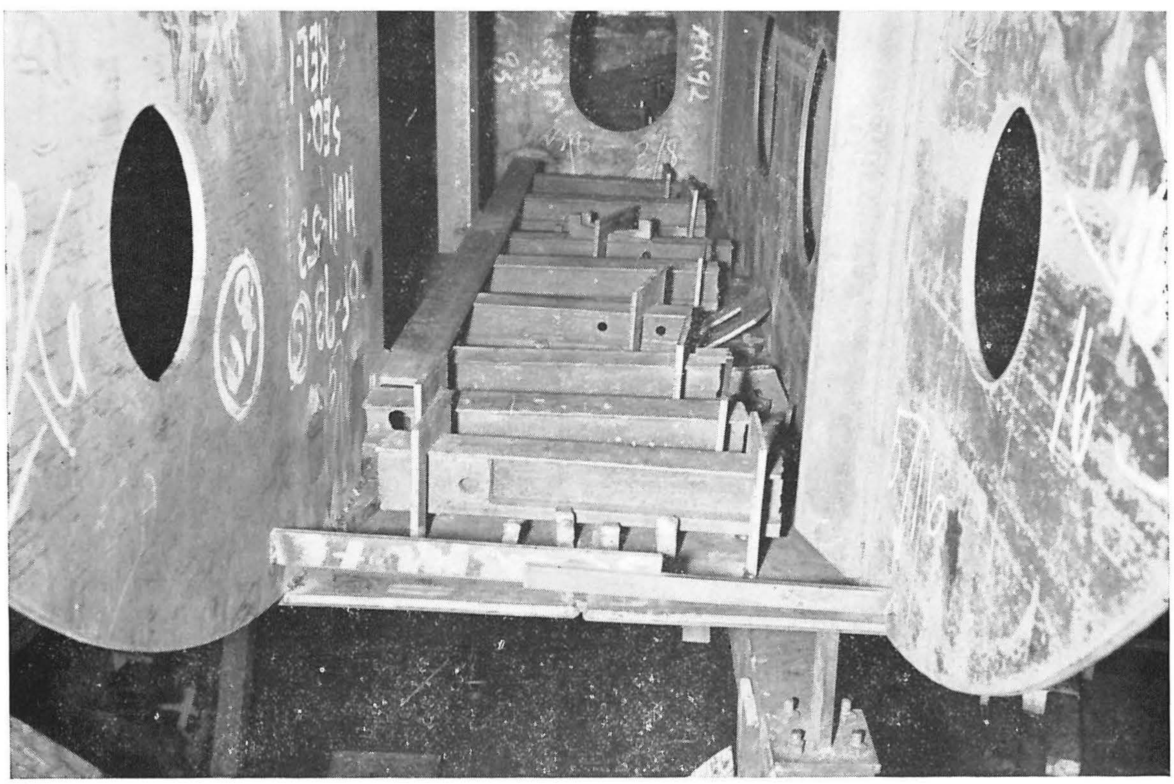
Double Bottom

After the first two flat bottom sections have been placed and welded, the first section of double bottom can be placed. The center line has already been placed on the flat keel. Guiding clips are welded along the center line to guide the vertical keel into position, and a clip is placed for the after end of the vertical keel to butt against.

When the crane lowers the section on the flat bottom, the double bottom is very close to its final location. Any movement to bring the double bottom section to correct position is obtained by jacking between shoes tacked to the flat keel and to the vertical keel. The center line on the section is checked by plumb bob to the center line of the flat keel. The midship line on the section is checked to the midship control point on the ways. The section is moved to correct location, and the vertical keel is pulled down to the flat keel with bolts and clips. The center line is checked again; then floors are checked for



Double Bottom Section on Tank Top. Note C. P. Machine.



Looking Into Double Bottom Showing Strongbacks Over Flat Bottom Butt Seam.

declivity, and the tank top is checked to see that it is level; and if everything checks, the keel is tacked in place.

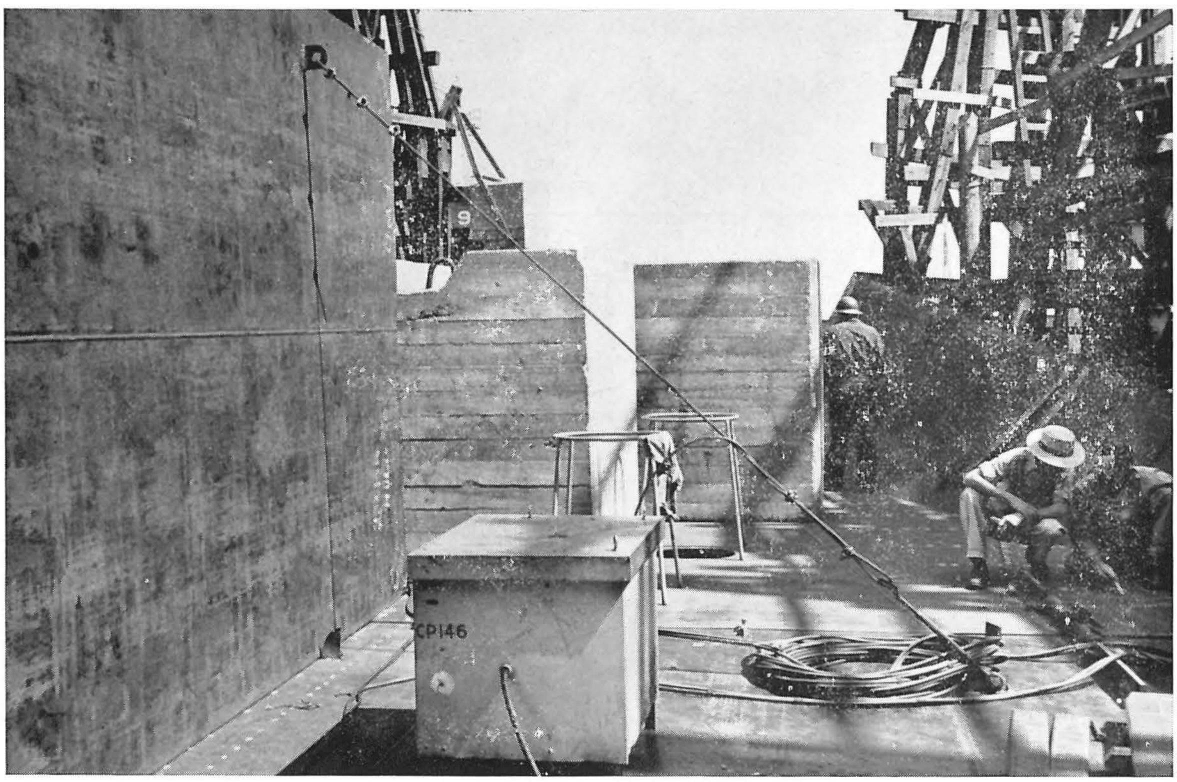
Next, the flat bottom is pulled to the floors and tacked. The floors are just pulled to a fair bearing because if they are pulled too tight, there is a tendency to distort the floors and shell during welding. As soon as three floors have been tacked each side of center, the welders start production welding. The keel is welded ahead of the floors, and the floors are welded from the center out. The intercostals are picked up as the floors progress.

Section No. 2 is landed aft, with the wild end butting against section No. 1. The section is set on center line by plumbing to the center line on the flat keel and by matching center line of section No. 1. Measurements are taken at the port and starboard edges from the midship line to the indicated bulkhead 108 line on the tank top. This is done to be sure that the indicated line is perpendicular to the center line. The difference between the measurement taken and the true distance of the bulkhead line 108 is the amount that the tank top must be trimmed and the section moved forward. The double bottom sections are located longitudinally by the floor corresponding to the bulkhead as the bulkhead must have proper bearing over the floor.

The double bottom section is pulled into place and the butt between the tank tops faired. The vertical keel is pulled down to the flat keel with bolts and clips, but before it is tacked the center line and the location of bulkhead 108 are checked. If they are all right, the vertical keel is tacked to the flat keel, and the welders continue aft through this section welding both sides of the vertical keel at the same time.

The remaining double bottom sections are similarly set, No. 3 section forward of No. 1 which does not have any bulkheads as it is set by frame 70. Bulkhead 68 is quite close to the aft end of the section, and the fitters also check to see that floor 54 is at the proper distance from the midship line.

The double bottom is fitted back to 158½, and the last section is usually left until after the stern casting and the last section of flat keel FK-15-A have been placed. In this way the double



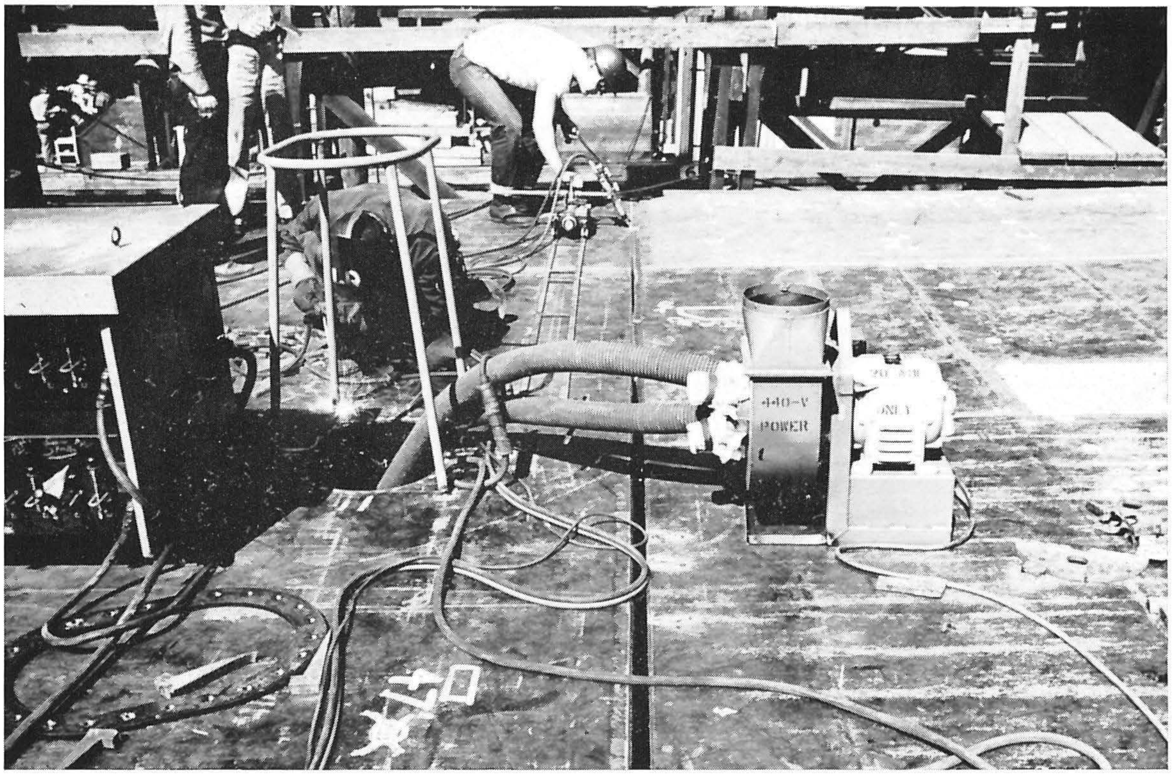
Weights Used in Setting Double Bottom.

bottom can be placed on top of FK-15-A and easily fitted to it. Otherwise, the FK-15-A has to be inserted under the double bottom, and if the latter is not quite on line, there is some trouble in fitting the two together.

As the placing of the double bottom progresses, the single V butt joints in the tank top are welded together from the top. Before the butts are welded, however, they are shored up from underneath so that the butt is 1/8" above the level of the tank top. After the weld is completed the shores are removed, and the top will return to a level position. A finish pass is put on the bottom of the butt, and it is completed.

Shipwrights shore the bottom of the hull as the floors in the double bottom are fitted and welded to the shell, and remove the buttock irons and timbers. The tank top is levelled by raising or lowering the shores. Cribbing is placed at the bulkheads and at the bilge, and the tank top is ready to receive the bulkheads.

Manholes are cut in the tank top as soon as they are landed to provide access and ventilation for the welders during construction.

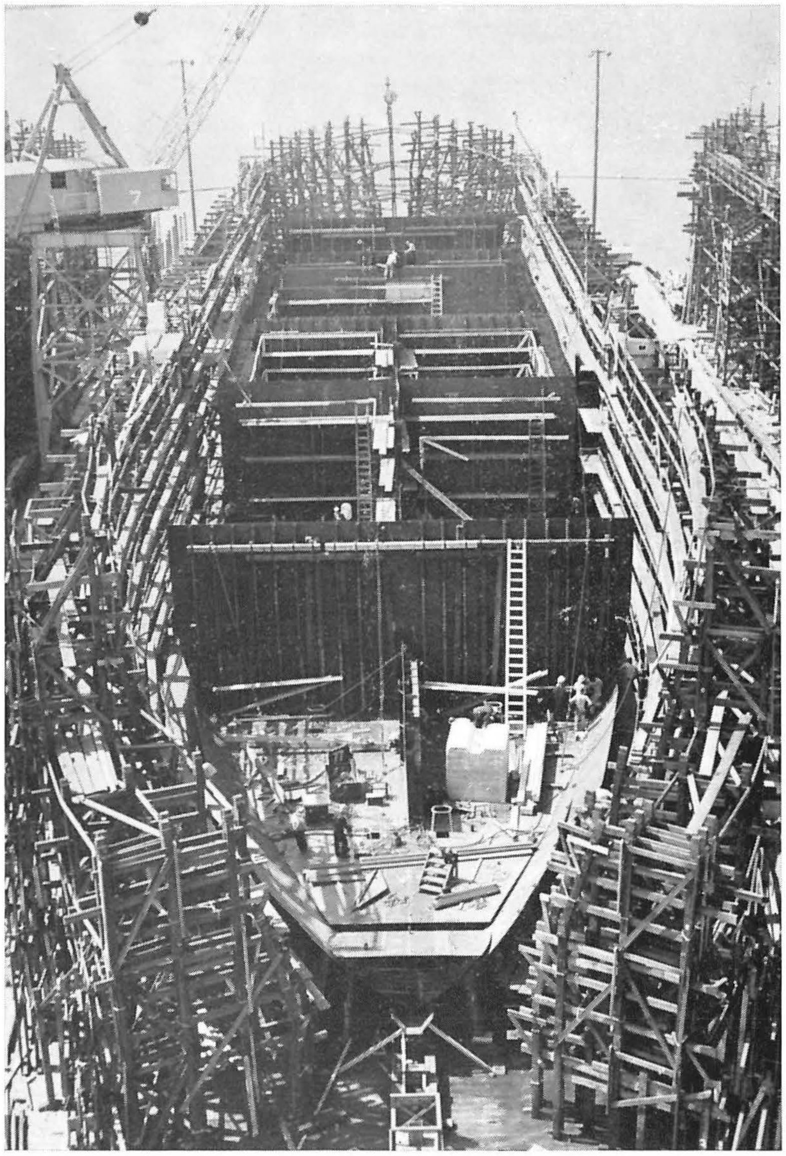


Trimming Tank Top Plate.

Transverse Bulkheads

Before the bulkhead arrives, the shipfitters tack a series of guide clips across the tank top along the line of the bulkhead. The clips guide the bulkhead to the proper location, and the shipwrights set it to declivity.

The bulkhead has been trimmed on both sides and on the top to the correct size, but the bottom is left wild so that it may be fitted to the tank top. After the bulkhead has been set to the proper declivity and the top has been levelled by shipwrights and engineers, the top is checked against the 6 foot water line to see that they agree. If they do not agree, it is the water line that is set to agree with the top of the bulkhead.



Transverse Bulkheads

The engineer sights a true 6 foot water line on the bulkhead at the center line, and the difference in rod reading to the true water line and to the 6′ water line marked on the bulkhead is the distance that the bulkhead has to be dropped to be in position. The bulkhead is scribed to the tank top and the excess material is burned off. Shipwrights lower the bulkhead to the tank top and set it to declivity. The top is checked for proper elevation, and the bulkhead is faired and tacked to the tank top by the shipfitters from the center line out. The welders start at the center and weld outboard, both sides simultaneously.

Center Line Bulkheads

Center line bulkheads are set after the transverse bulkheads are in place. The bottom of the bulkhead has to be scribed to the tank top because the top of the bulkhead must be flush with or just a fraction below the transverse bulkhead and have the proper declivity so that it will fit under the second deck. The slots for the second deck beams must be in the proper location so that the second deck can be set properly.

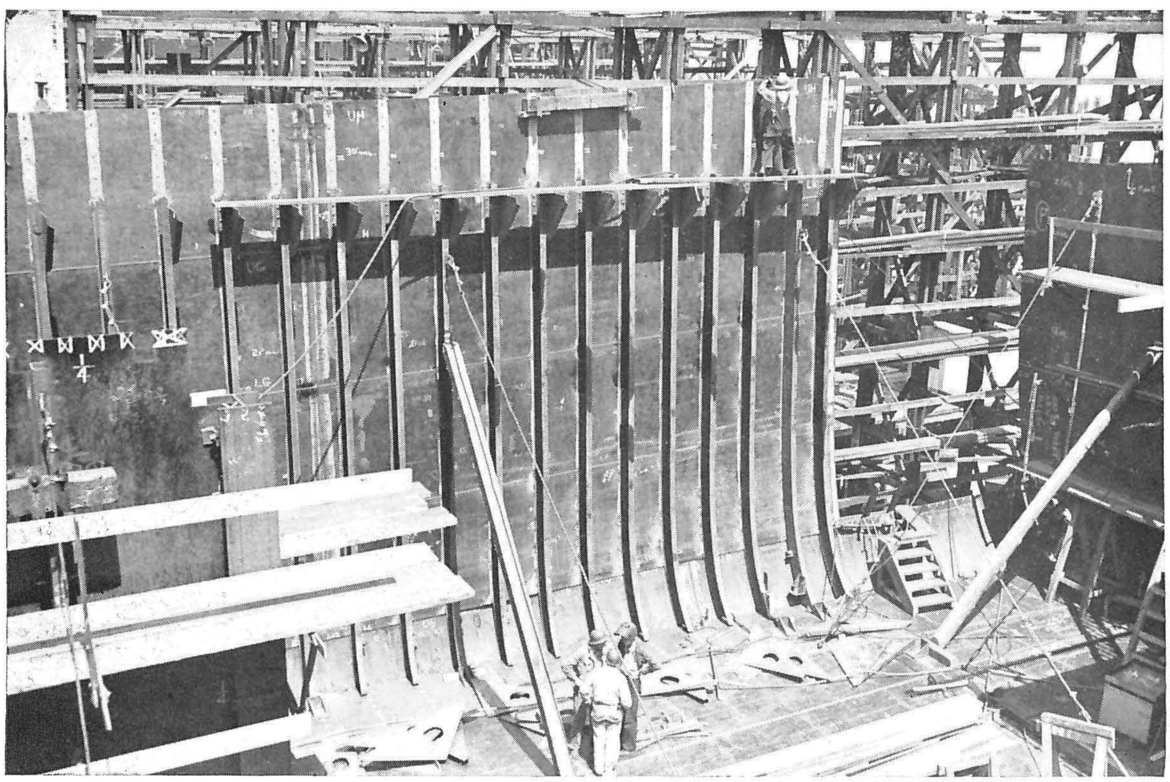
To accomplish this, the bulkhead is set at the proper declivity and fitted to the transverse bulkhead which is also on declivity. The bottom is scribed to fit the tank top. After cutting along the scribed line, the bulkhead is dropped till its top is flush with the top of the transverse bulkhead.

This center line stanchion is fitted to the edge of the bulkhead and held there with clips. After the stanchion is set, the bulkhead is welded to the tank top with intermittent weld and welded 15″ up the transverse bulkhead from the tank top, to clear the tank top for testing. It is not welded the rest of the way until after the second deck has been set, in order that any buckles that occur after the deck is placed can be easily removed without having to cut any welds.

Side Shell

Erection of the side shell is started just as soon as bulkhead 68 and 88 have been fitted to the tank top. The crane lands section No. 1 from frames 68½ to 92½ either port or starboard on the hull, and the shipwrights brace it in position slightly high and inboard.

The shell section is first set in proper relation to the midship line by checking to frame line 88 on the shell. Then the engineers check the top of the shell section against the 27 ft. water line, and if the water lines do not check, they are adjusted to the upper edge of the H strake, which is the top of the shell section.



Side Shell Section No. 3 in Place.

The top of the shell is checked for location against the top of the transverse bulkheads by stretching a piano wire between bulkheads. The shell is lowered to bring the water lines and upper edge of the shell to the proper height and in the proper relation to the bulkheads. Also the bottom is jacked out to the proper half-breadth and tacked to the D strake.

The shell is now in the proper location and ready for the fitting of the D-E seam. By means of bolts to clips on the frame, the D plate is pulled in tight against the side shell and trimmed along the bottom of the E plate. The D plate is pulled in the remaining amount at the same time that it is wrapped in tightly against the frames. The D-E seam is then fitted and strongbacked on the inside. It is not tacked, but welding can commence immediately on the inside, the seam being completed as welding proceeds.

The margin brackets are placed as soon as the D-E seam has been strongbacked. They are all placed in position at the frames on a line 48″ inboard from the edge of the tank top and then checked to see that they have a full 3″ lap on the frames. If there is not a full 3″ lap, they are all moved back slightly to secure the full 3″. The brackets are then welded to the tank top, but they are not welded to the frames until after the second deck has been set.

The tank top gusset plates which tie in all the margin brackets fore and aft are placed after the margin brackets have been set. Actually th 4″ portion of the gusset plate adjacent to the inner bottom plating can be set first, and the margin brackets can be set to it. However, if the brackets have to be moved, the gusset plate has to be reset. Originally, the gussets were plug welded to the bracket flanges through two 1″ holes, and the brackets were welded to the underside of the gusset. A satisfactory weld cannot be obtained under the gusset, so the gussets are now welded to the bracket flanges through slots.

The port and starboard sections of erection section No. 2 between frames 92½ and 116½ are then set. Section No. 2 is set similarly to No. 1, except that since the after shell top on No. 1 has been accurately set, the forward top of No. 2 is set to the same height. The after end is set from bulkheads 108 and 116 by taking the molded line offset from the upper edge of the H strake down to the molded line of the second deck, which is the top of the bulkhead.

To set Section No. 2 longitudinally, the frames are checked to the bulkheads at 88 and 116 and to the midship line, and the distance from the after edge out to the location of the hatch end beam of section No. 4 is checked. Also the frame spacing across the butt to No. 1 is checked. The D-E seam is fitted and welded as in No. 1, and then the vertical butt is fitted and welded on the inside first.

The remaining sections are similarly set by checking the frame spacing at the butt, the distance from midship to the location of the hatch end beams, and the height at the butts, as before.

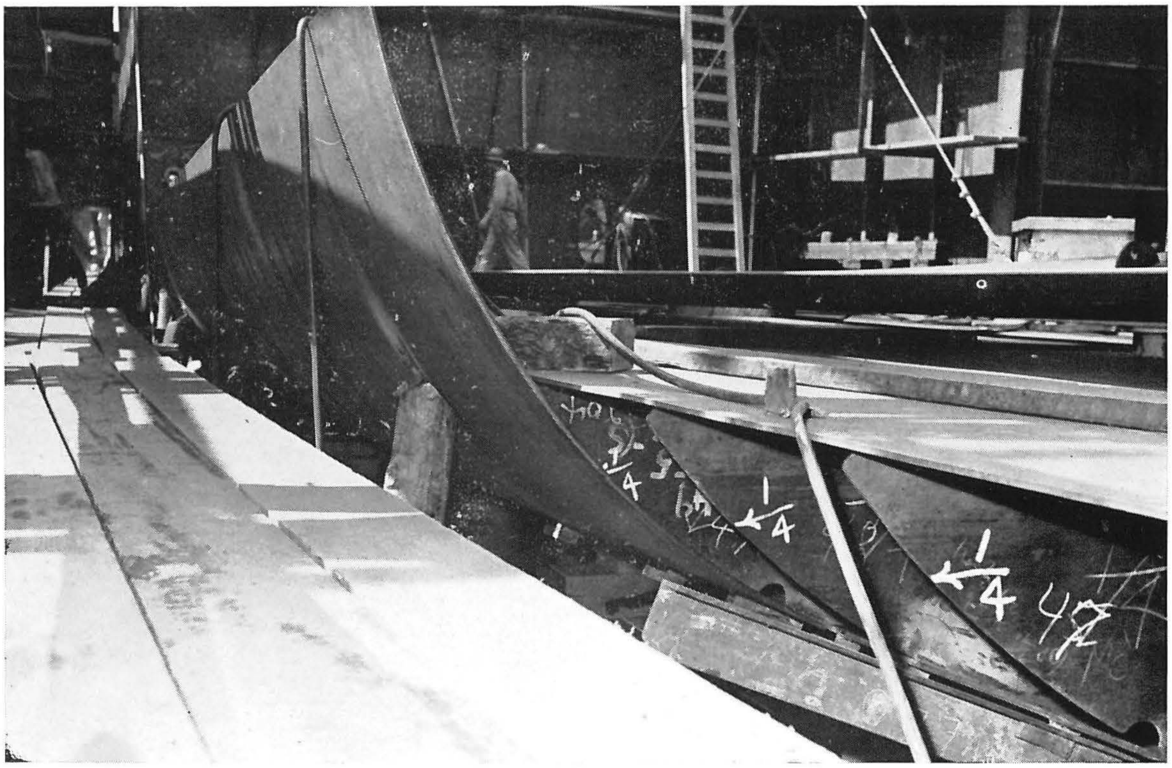
As soon as erection has been completed a crew rivets the No. 6 erection section, the E-2, F-2, G-2, and H-2 plates, and the J strakes. All the other shell riveting is done on the skids.

D Strake

The plates of the D strake are set individually, starting with D-9 amidship and working forward and aft. If possible the welding should be completed in the inner bottom before they are placed because they cover over the ends of the floors which cuts off easy access to the double bottom and ventilation from the sides.

A slot in an angle iron is hooked over a clip welded to the C strake, and the angle iron forms a rest on which the bottom of the plate is slid against the edge of the C plate. Then bolts from clips welded to the tank top and to the floors pull the D plate in so that it wraps around the end of the floors. The D-C seam is fitted, and the D plate is pulled in tight to the tank top and tacked. The D-C seam and the butt are welded inside and then the floor plates are welded to D. The outside is back-chipped and completed with the rest of the shell.

The D plates all come neat on the ends except the forward and aft plates, and it is advisable to check each plate back to the midship line as it is set.



Setting D Strake

Second Deck

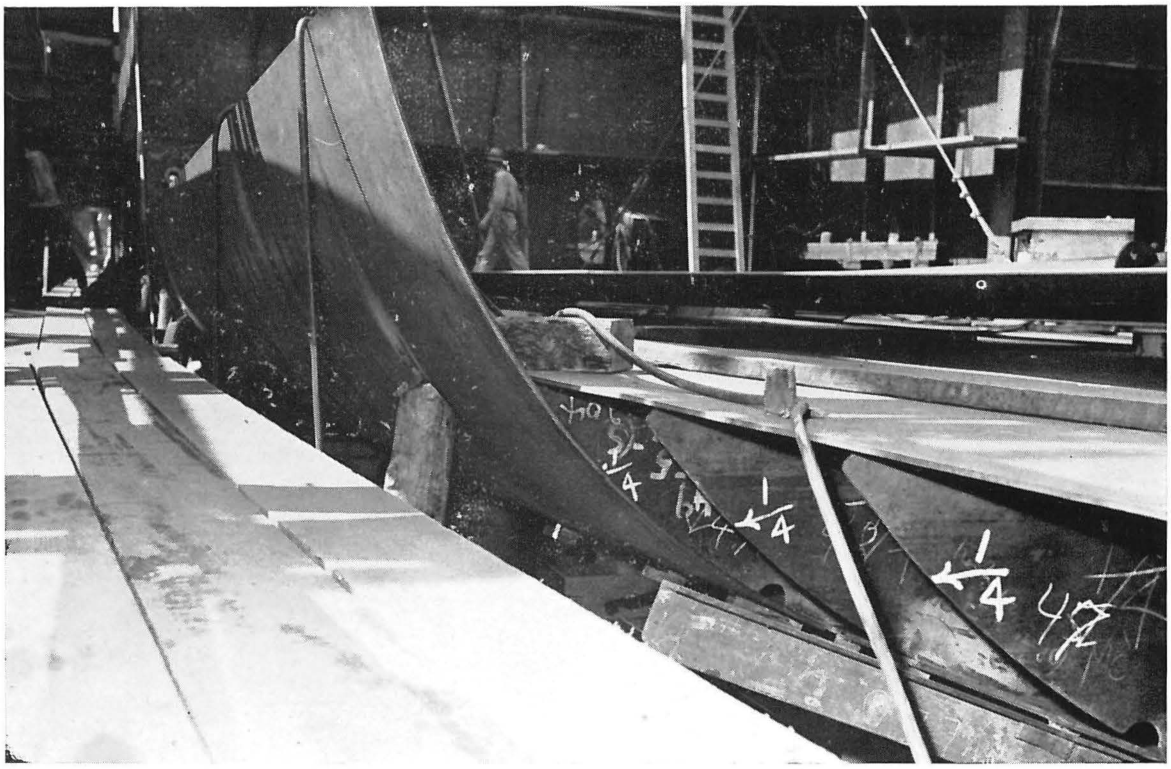
The second deck is divided into transverse sections fore and aft of the hatches and into longitudinal sections that form the deck along the sides of the hatches. The transverse section at the midship end of the hatch is set first and fitted, then the transverse section at the other end of the hatch is set in place, and last the two longitudinal sections are set.

When the crane lands the first transverse section, the fitters guide the section into place with the hatch end beam resting on the center line stanchion and with the longitudinal girders resting on the bulkhead stiffeners.

The deck section is located longitudinally by measuring from the hatch end beam to the midship line which has been carried up on the shell by using plumb lines. The section is centered on the hull by plumbing down to the tank top center line at both the fore and aft ends. While the section is being located, a check is made to see that the deck beams match with the brackets on the frames. The section can be adjusted a small amount to fit the frames, but any appreciable movement will throw the hatches out and cause trouble with the remaining sections.

The height of the bulkhead was carefully checked when it was set so the height is accepted as satisfactory, and the deck is set to that elevation. The section is pulled down to the correct elevation which should bring the deck plate on top of the frames. The entire section is tacked as soon as it is in the correct location, and production welding to the supports and to the side shell can commence. The deck beams are welded to the brackets but not to the shell frames.

The longitudinal girders are welded to the bulkhead, and the knee brackets are added. At the center line bulkhead, the deck beams are welded to the bulkhead plate around the outside of the angle. The bulkhead stiffeners have a 2″ landing on the beam and are welded all the way around. The hatch end beam is welded to the top of the stanchion, and after the second deck is fitted and welded, the center line bulkhead is welded to the stanchion and to the transverse bulkhead. The hatch end beam



Setting D Strake

Second Deck

The second deck is divided into transverse sections fore and aft of the hatches and into longitudinal sections that form the deck along the sides of the hatches. The transverse section at the midship end of the hatch is set first and fitted, then the transverse section at the other end of the hatch is set in place, and last the two longitudinal sections are set.

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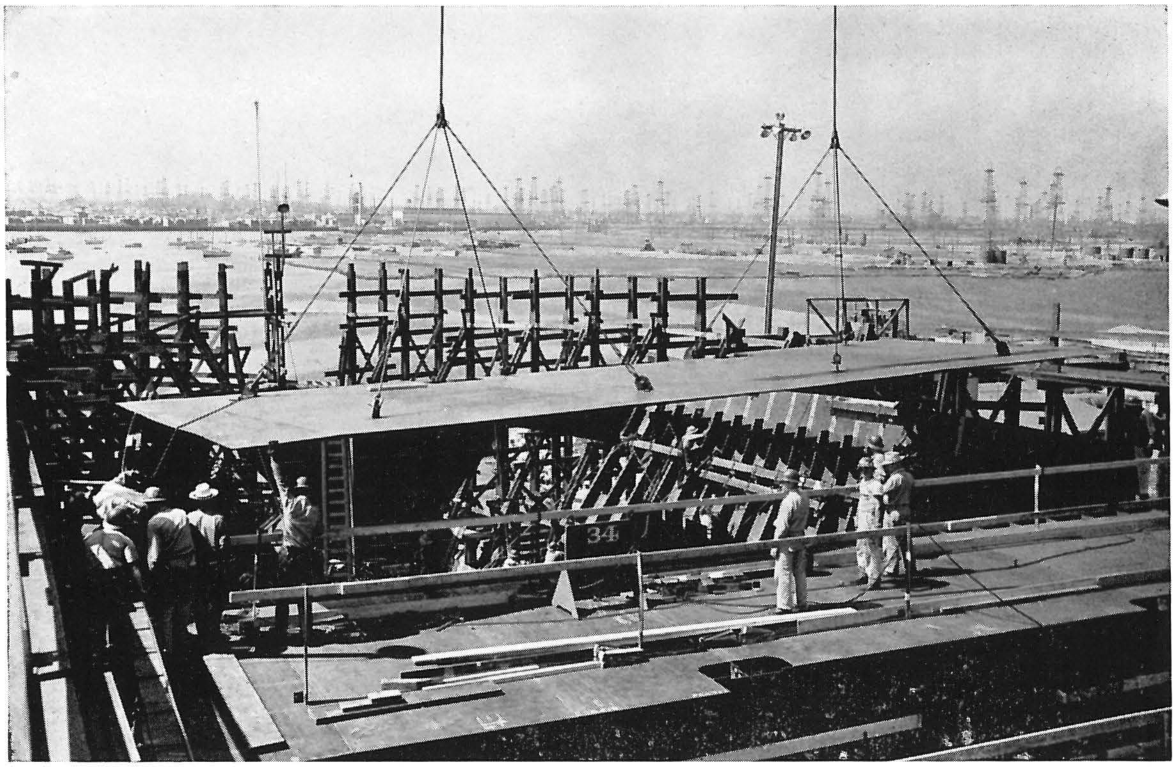
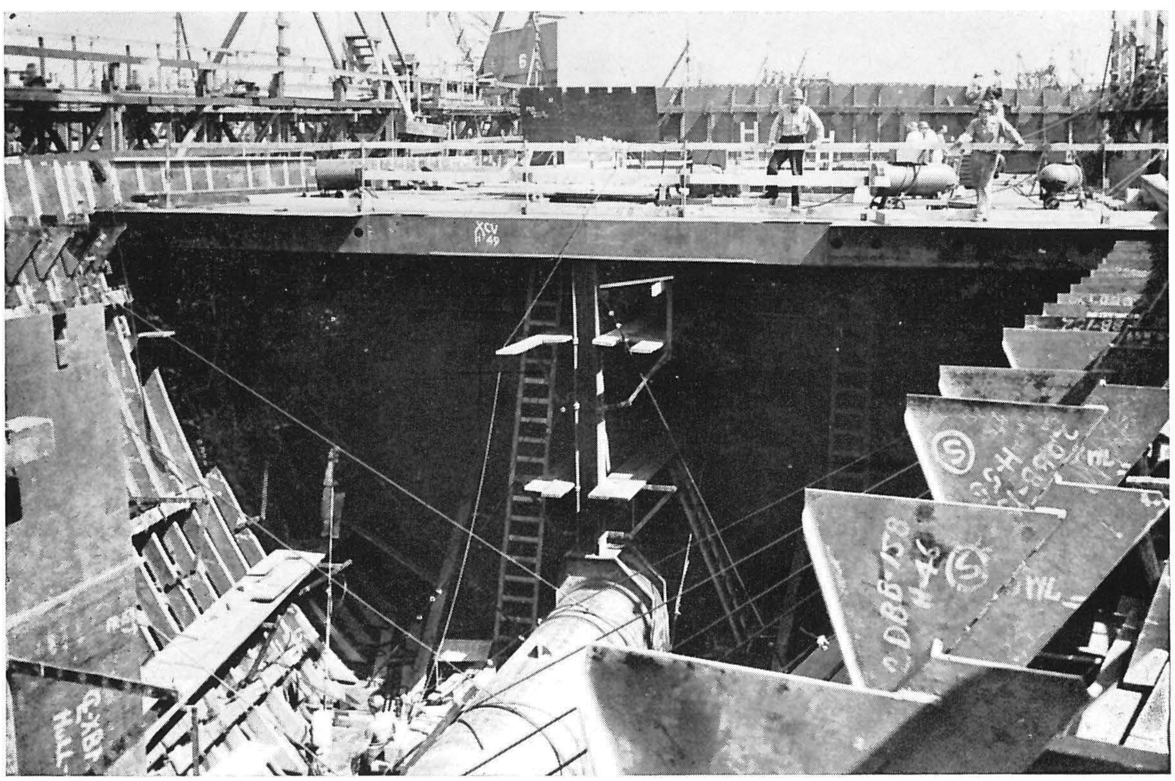


Crane Lowering Second Deck Section.



Second Deck Section in Place.

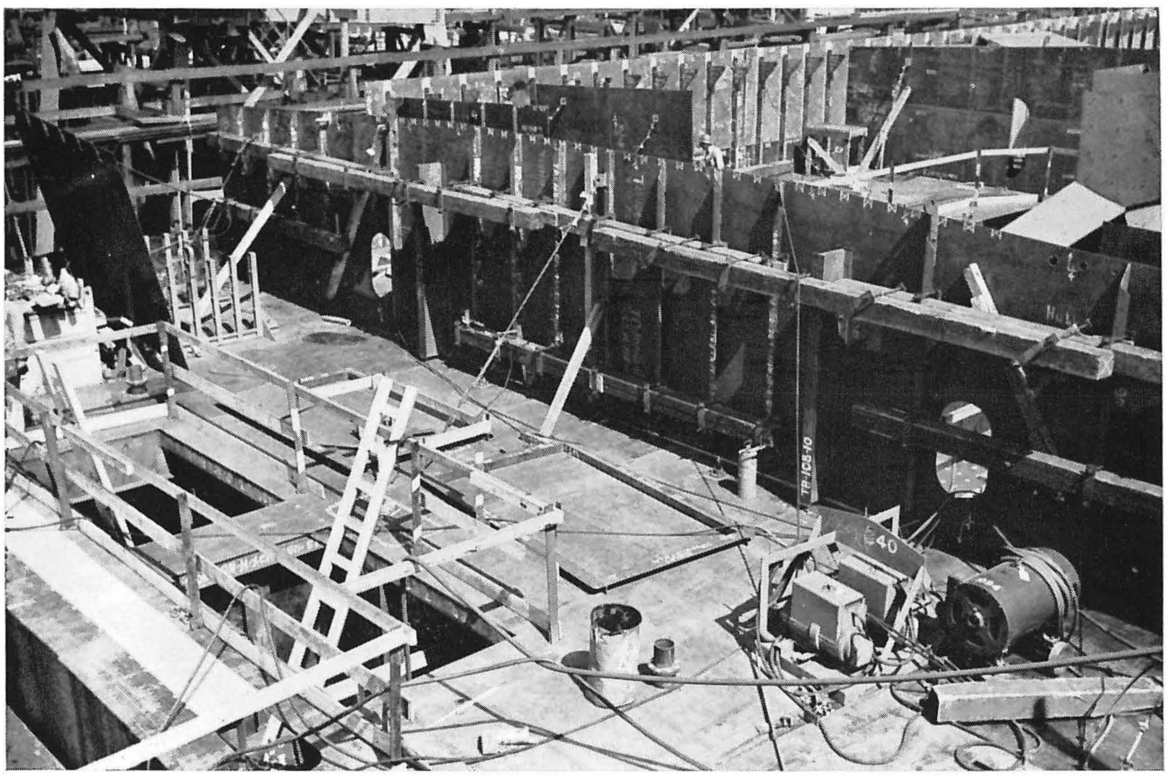
brackets, the tilting brackets, and the brackets under the deck beams at the bulkhead stiffeners are placed.

As soon as the first section has been fitted and tacked, the opposite transverse section is set in place a quarter of an inch or so out from the final location so that the longitudinal sections will slide in easily. After the two transverse sections are in place, the distances out to the hatch side beams are measured. Then the two longitudinal sections are set in place on shores, and the sections are all fitted. The hatch is carefully checked to see that it is square, and the location of the hatch end beams is checked to the midship line.

After the second deck is in place, the bulkhead stiffener clips are welded to the tank top below.

'Tween Deck Bulkheads

Starting with No. 88, the transverse 'tween deck bulkheads are erected as fast as the second deck sections are placed and tacked. The location is laid out on the second deck from the midship line and guide clips are set. Each bulkhead is landed by the crane, and the shipwrights set it to the proper declivity and level it. The top is carefully checked to see that it is level, and then the water lines are checked against the top as with the major bulkheads below. The molded height is checked, and the bulkhead is scribed along the second deck an amount sufficient to bring the bottom to the second deck. The bulkhead plate is burned off, and the bulkhead is fitted to the second deck after the location from the midship line and the declivity are checked. The welders tack and then weld the bulkhead from the center line out.

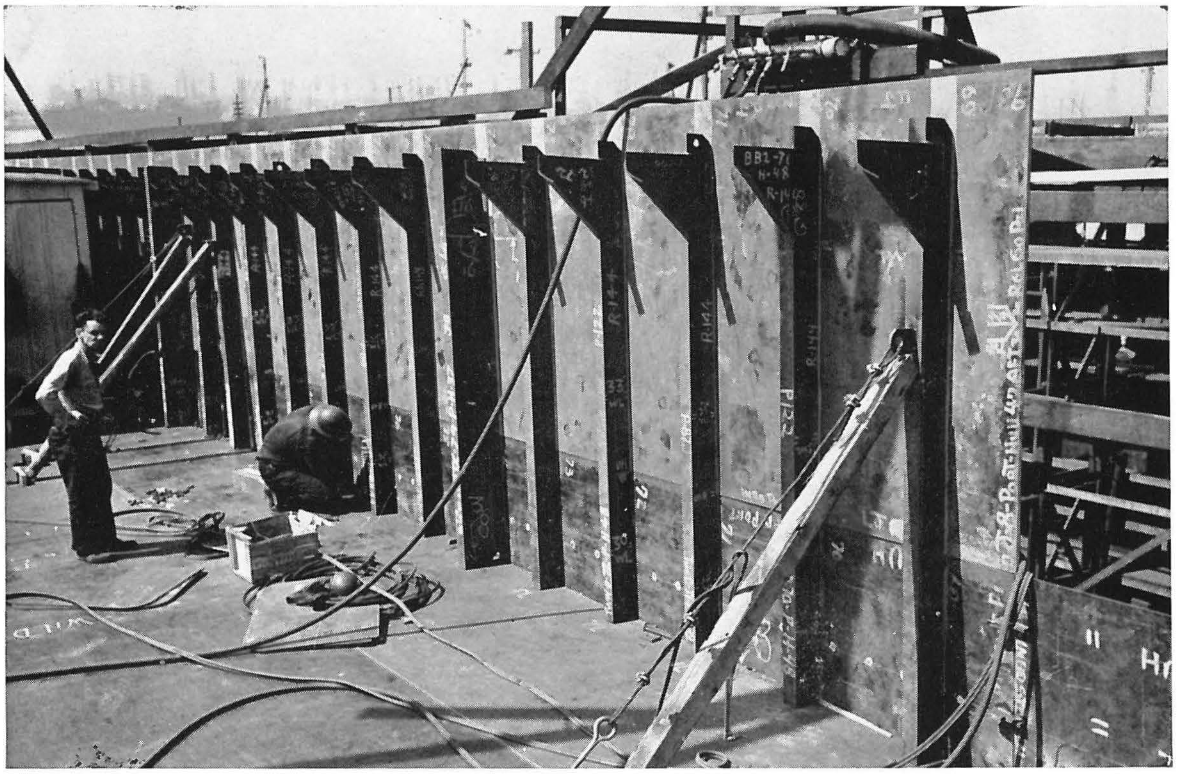


'Tween Deck Bulkhead 108.

J Strake

The J strake comprises the port and starboard side shell between the second and upper decks. The individual plates come from the sub-assembly with the 'tween deck frames bolted to them.

Erection starts amidship with plate J-9 and proceeds forward and aft. The frames are bolted to the top holes in the H plates of the side shell sections. The top of the J plate and the upper deck brackets are checked against the top of the 'tween deck bulkhead for the proper height and the frames are checked against the midship line. The frame spacing must match that of the side shell. If any errors have been made in the setting of the side shell, they will show up here. And if there is an error, it may be necessary to plug weld the rivet holes and redrill them. The rivets are driven with the side shell sequence 6 and the E-2, F-2, G-3, and H-3 plate.



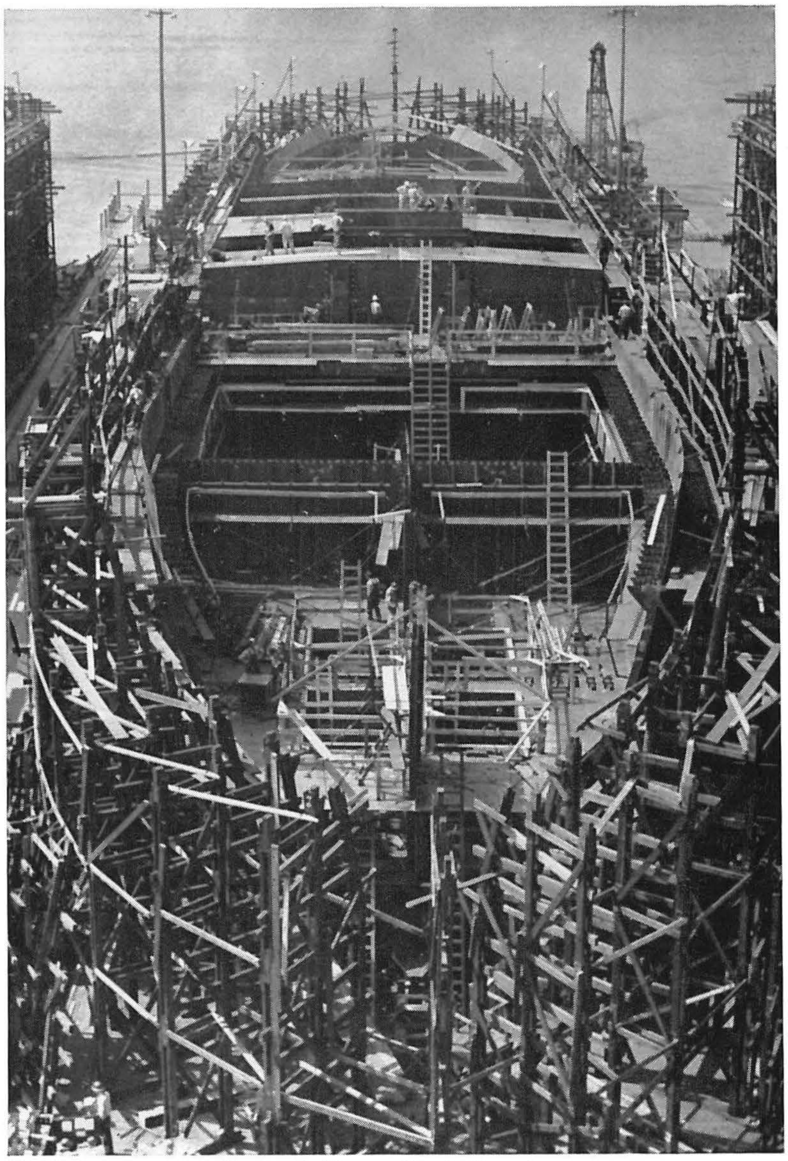
Setting J Strake.

Upper Deck

The upper deck is divided in the same manner as the second deck and is set in much the same manner. After the 'tween deck bulkheads amidship, the machinery casing bulkheads, and the miscellaneous bulkheads between bulkheads 88 and 108 have been set, the two longitudinal deck sections XEP and XEQ are placed.

Since the tops of the 'tween deck bulkheads were carefully checked and the top of the J strake was set to the correct height, the upper deck is set from them. The two sections are set longitudinally from the midship line and transversely from the center line of the hull.

The transverse sections XEN and XES are set next. Their erection is quite similar to that of the second deck except that there are no center line bulkheads, and the hatch end beams rest on center line stanchions which are placed after the beams have been landed.

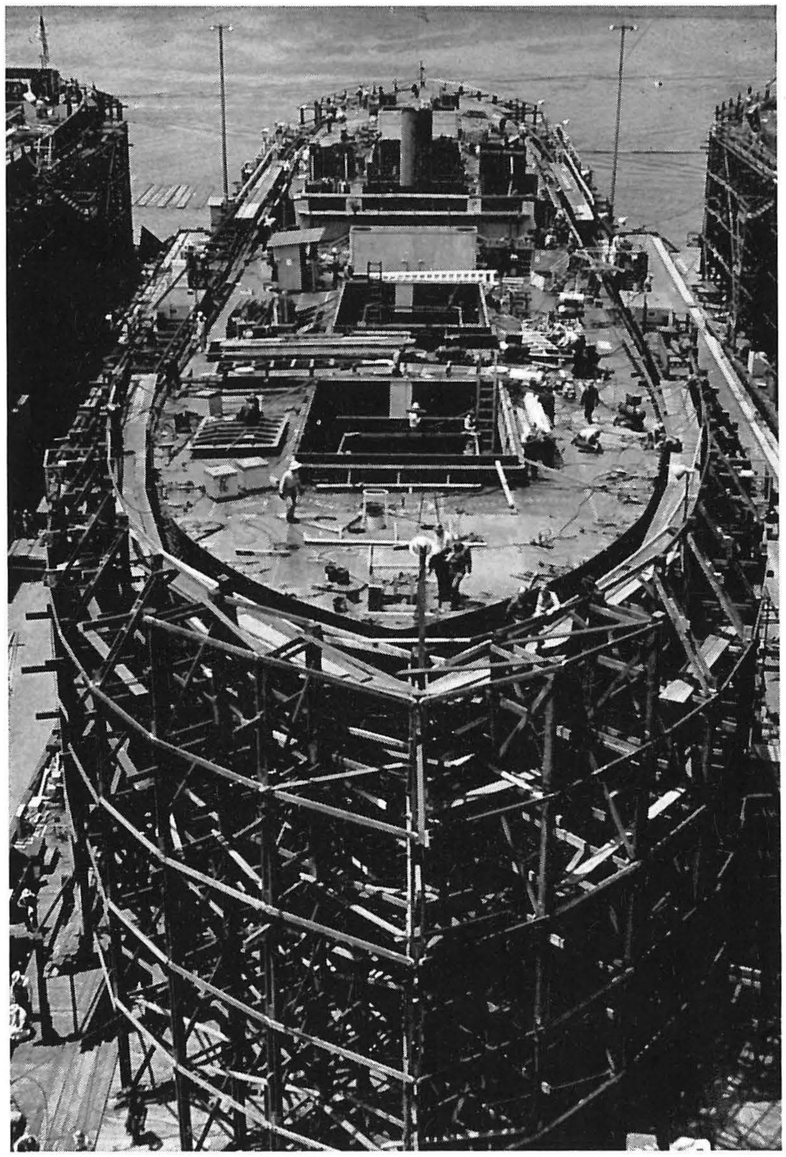


Start of Upper Deck Erection.

Superstructure Erection

The superstructure consists of the deck house running from frame 83 to 113, the after deck house from frame 163 to 174, and the three mast houses. The midship deck house has three decks above the main deck. In the main deck area are crew's quarters and officers' mess. Above this is the boat deck house, which is smaller and contains the officers' accommodations. On the bridge deck are found navigating bridge, wheel house with chart room, captain's office, and captain's quarters to starboard. On the port side are the radio room and operator's quarters. On the top of the house are the compass platform, flag lockers, signal hoist, and two machine gun platforms.

In the after deck house are the accommodations for the gun crew and for the hospital. On the top of house is found the after gun, two machine guns, emergency steering station, and binnacle. The three mast houses are used for paint and gear storage. They are located at frames 39, 68, and 135.



Start of Superstructure Erection.

In the erection of the midship deck house, the first bulkhead landed is the transverse bulkhead at frame 83. This is set on declivity by shipwrights. The height is checked by the layout man scribed and burned. The longitudinal bulkhead from 83 to 113 is landed in three major sections and four minor, which are set on declivity and scribed to the correct height. The engine casing and boiler casings are then fitted to the deck. All secondary bulkheads are landed, faired, and fitted in this area before the boat deck is landed. The galley range and steam table are landed in the galley but are not placed. The engine casing extends above the boat deck to form the coaming for the engine skylight.

The boat deck is landed by the cranes and supported by shores. The transverse location is checked by plumbing the center line fore and aft to the main deck, and the longitudinal location is checked by measurement from the midship line. The deck is set to declivity and sheer by the shipwrights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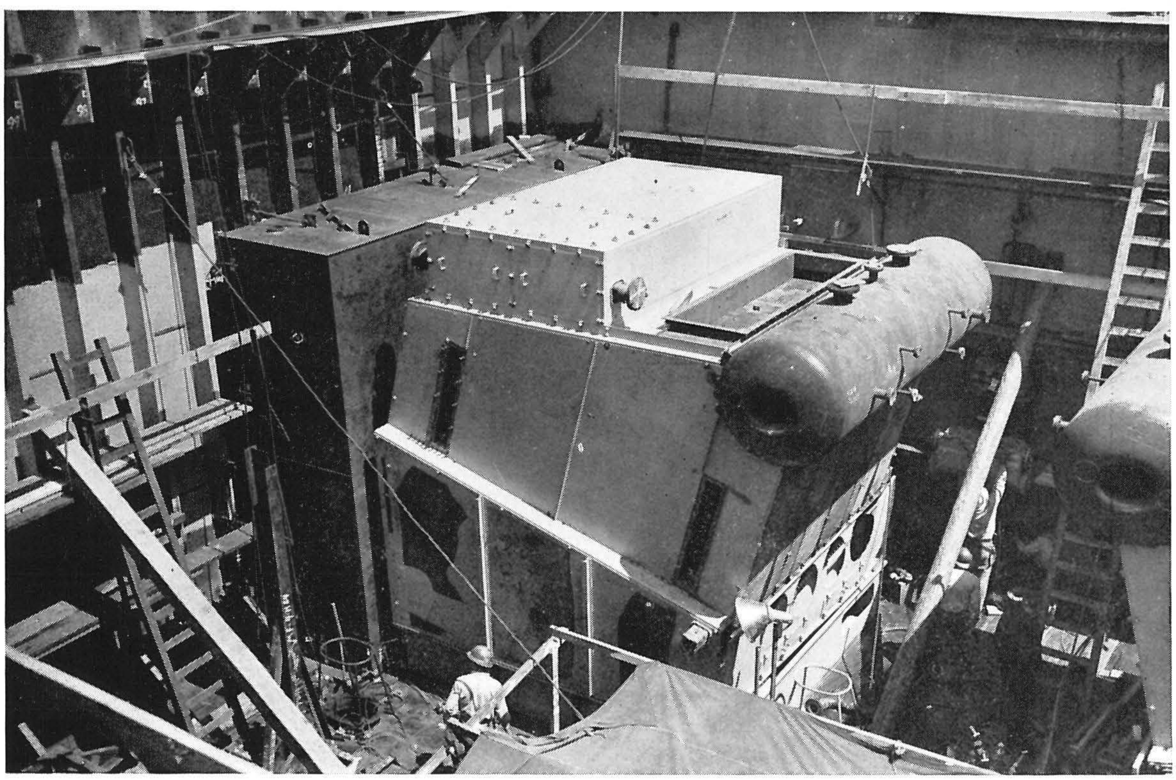
and is then fitted and faired to the deck house bulkheads. The boat deck house runs from frame 83 to 102, and erection is similar to that of the main deck house.

The bridge deck, the bridge deck house and the bridge deck top, and the after deck house are all erected in the same manner as the boat deck house. The mast houses are assembled as a unit. They are set to declivity and to sheer by the shipwrights. Measurement of height is taken at the high side of the house. The house is fitted to the deck by the shipfitters on the inside only to prevent scoring the face with the weld on the clips and bolts. Before the mast houses are placed, the mast doubler plate has been fitted and tacked to the deck. This must be a metal to metal bearing. The plate is plug welded to the deck by a series of holes and welded all around the outside. On plug welding the plugs are half filled and then peened while still hot to remove gas and slag pockets. They are then filled the balance of the way. The excess is chipped and ground flush. In welding of watertight and non-watertight door frames in houses, a downhill bead is used to keep distortion and warping to a minimum.

Fuel Oil Settling Tanks

The fuel oil settling tanks are set in place as soon as the side shell is fitted so that the boilers may be landed. Each tank comes from the sub-assembly with three sides and the top welded together. The tanks are against the shell, port and starboard of the boilers.

As soon as the margin brackets are welded to the frames, the tank is pulled into the frames, set on declivity, and scribed for correct height. The frames are cut and the tank is fitted to the frames and to the side shell. The tank should be welded as soon as possible after it is fitted; otherwise there is a tendency for the frames to buckle inboard as the load from the structure above is increased.



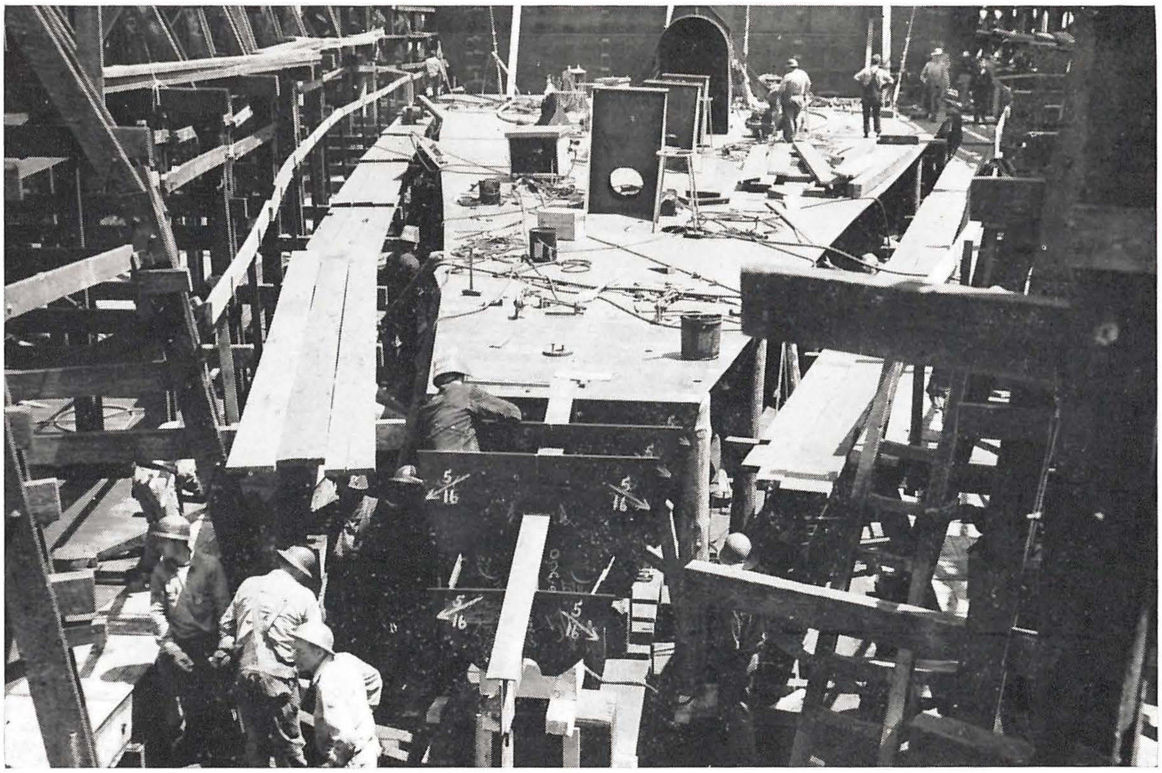
Fuel Oil Settling Tanks and Boiler in Place.

After Deep Tank and Shaft Tunnel

As soon as bulkhead 108 has been fitted and tacked to the tank top, the tunnel thrust recess is moved up to the bulkhead and scribed to the tank top. However, it is not tied to bulkhead 108 until the center line bulkhead has been placed. Then bulkhead 112, which is the after side of the recess, is set and fitted. The shaft tunnel is placed and bulkhead 116 is set over the tunnel and fitted to the tank top. The center line bulkhead XBJ, with the tunnel escape attached, is set in between bulkheads 108 and 116. The two bulkheads are setting on declivity, and it is a help in setting XBJ if the crane slings are adjusted so that XBJ is at the same declivity when it is swung in place. The transverse after deep tank horizontal girders are placed with the transverse bulkheads. The longitudinal girders are placed independently and should be set in the tanks before the second deck is placed.

The pipefitters place the heating coils on top of the tank top as soon as the double bottom has been placed. Also the shaft tunnel is set to the tank top as soon as the double bottom sections are far enough ahead. Each of the two sections of tunnel are scribed to the deck, fitted, and welded to the tank top. After the tunnel is welded, the rivet strap is faired to the dome. Rivet holes are reamed and the dome is cut loose from the tunnel by cutting the stiffeners.

After Deep Tank Showing Thrust Recess and Center Line Bulkhead.



Shaft Pedestals and Shaft Tunnel

Forward Deep Tank and Forepeak

The forward deep tank bulkheads and top are all assembled on the skids. They have to be placed in a set sequence because the stiffeners of bulkhead 39 are cut to receive the tank top plate and the beams of the tank top are cut to receive the center line bulkhead plate.

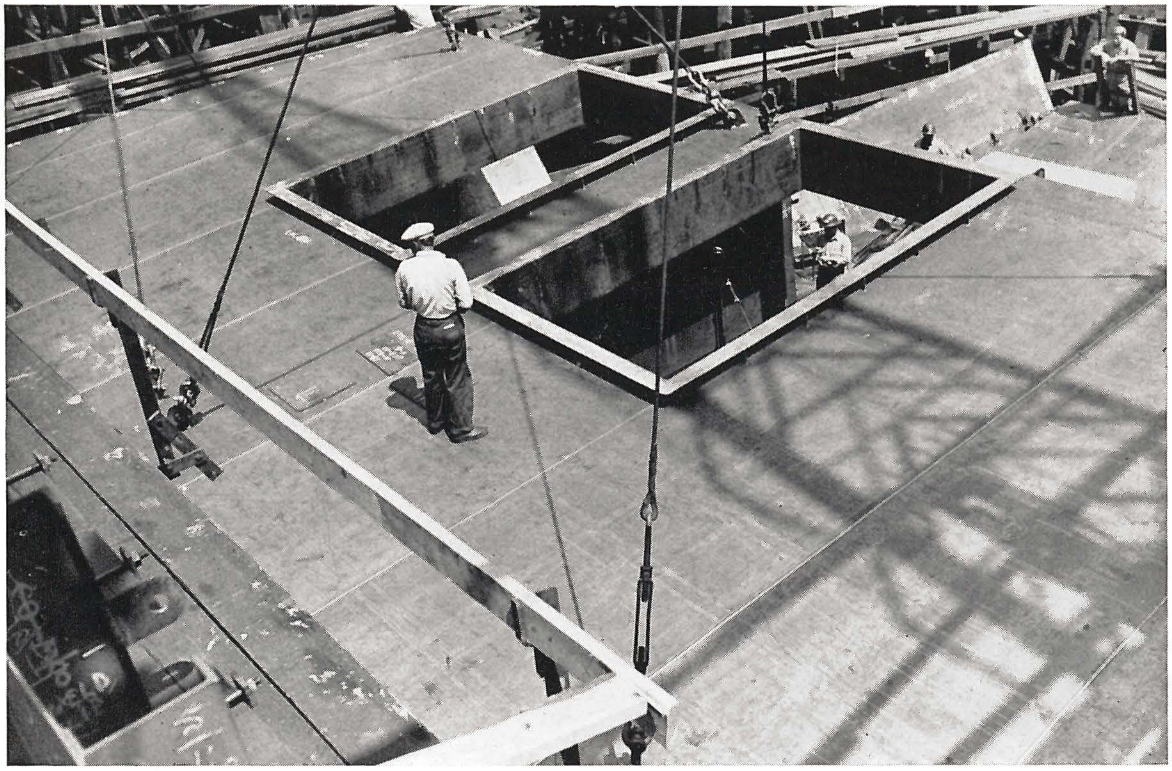
After bulkhead No. 39 is in place and tacked, the center line bulkhead forward of 39 is set and scribed to the tank top. Then it is moved 16″ forward, and the after half of the deep tank flat is set on the bulkhead and the two of them are moved back into place while the crane holds the weight of the deep tank flat XBBL. In this way the XBBL moves horizontally into the slot in the bulkhead stiffeners.

After the deep tank flat has been moved into place, bulkhead 25 is set in the same manner as any transverse bulkhead. A wire is stretched from 39 to 25 and the outboard edges of the deep tank flat are set to the correct height. Then the side shell frames are set from the tank top up to the deep tank flat. The D strake is already in place, and as soon as the frames are set they are tacked to the D plate and the margin brackets are set.

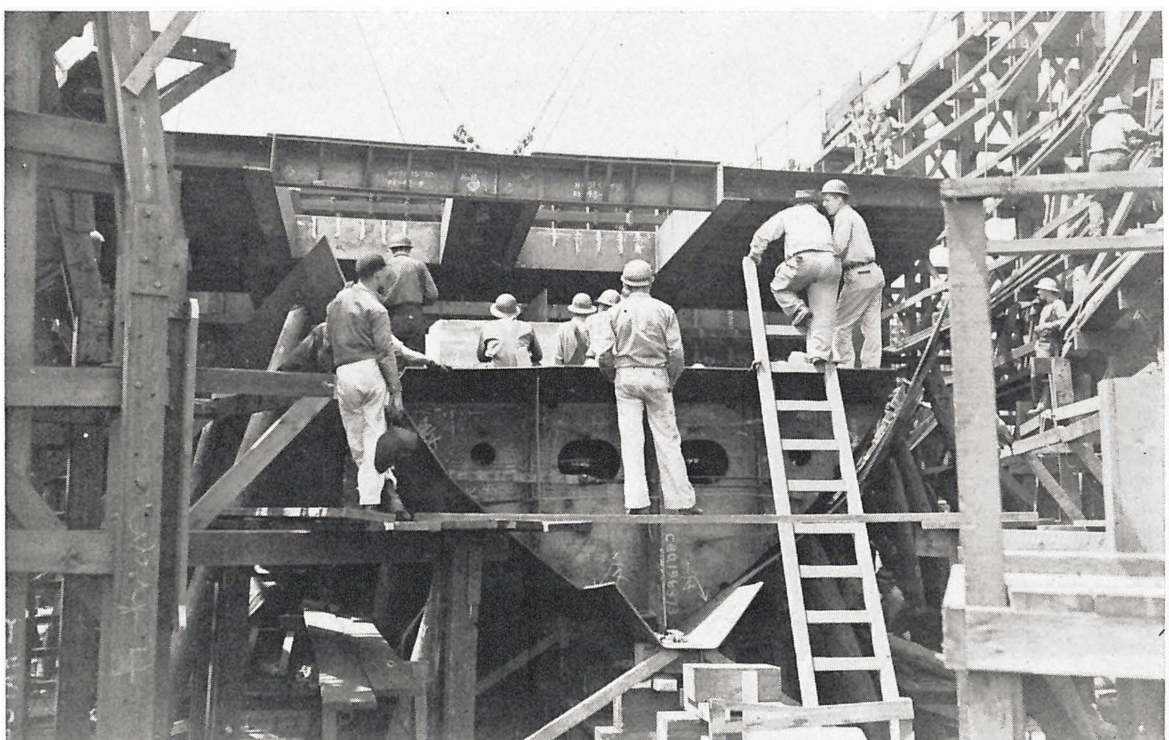
Next the center line bulkhead from 25 to 12 is set and the forward half of the deep tank flat is placed. The shell frames are set as before except that bulkhead 12 is not there, and the forward end of the wire is located from the ways.

The center line bulkhead is set on the deep tank flat at bulkhead 39, and side shell erection section five is placed. Side shell plates E-2 and F-2 just forward of section No. 5 have the frames bolted to them at the head of the ways, and they are set in place and then supported by cables and shores. The center line bulkhead on top of the deep tank aft of bulkhead 12 is placed, and the second deck is carried out to bulkhead 12. As soon as all of the assembly up to bulkhead 12 is tacked and partially welded, the hull is ready for the forepeak.

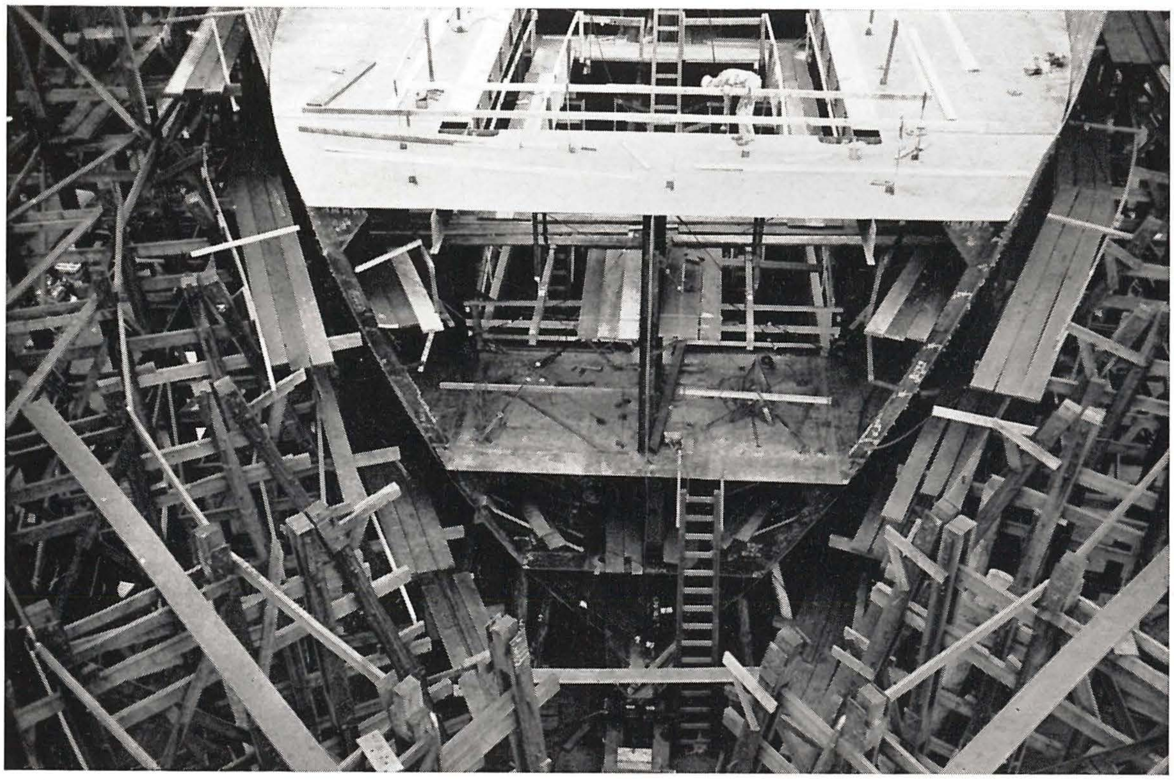
The forepeak is supported on blocking and shores. Cables are run from the deck over timber piers to anchor clips on the second deck. The shipwrights set the forepeak to the proper declivity,



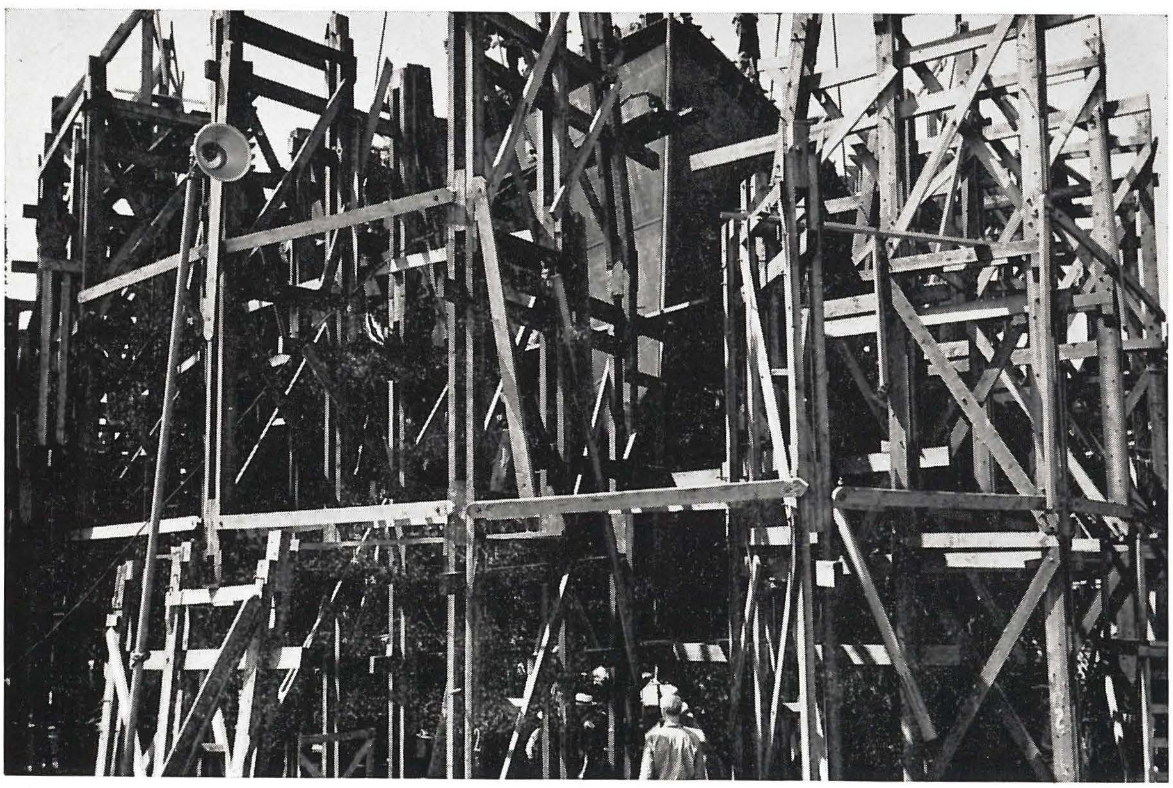
Lowering Forward Deep Tank Flat to Place.



Lowering Forward Deep Tank on Centerline Bulkhead.



Hull Ready for Forepeak.



Forepeak in Place.

elecation, and center line of the hull except that the whole assembly is several inches forward of its final location. Then a check is made of how the forepeak fits on the port and starboard side of bulkhead 12, the heights at the second deck, the declivity from frame 12 to the stem bar, and the declivity of bulkhead 12. The forepeak is moved into position and a final check is made of the spacing between frames 12 to 13 at the vertical keel, tank top, deep tank flat, center line bulkhead, and all along the edge of the second deck. Using this data as a guide, any necessary adjustments are made in the location.

The interior framing and then the shell are fitted. The welding is carried forward from the rest of the hull and completed in sequence.

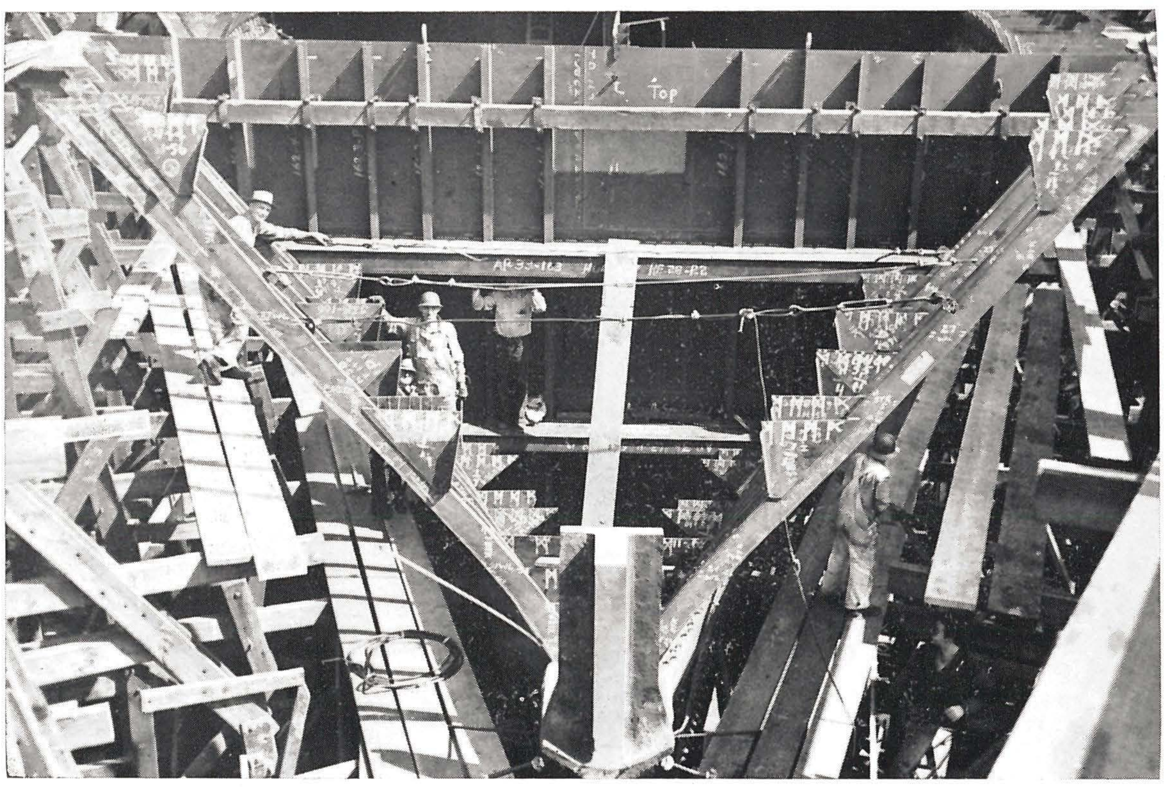
After Peak and Fan Tail

The after peak is referred to as that portion of the hull from bulkhead 162 aft. At the present time only the fan tail is sub-assembled and the flat keel FK-15A is welded to the stern casting before erection. However, as soon as sufficient area is available, the whole after peak will be broken into several sub-assemblies.

Before the after peak erection starts, the next to the last section of the flat keel FK-15 has been laid and the flat bottom XAT has been set on it. The last section of the flat keel FK-15A is assembled with the stern frame in the gantry crane way and then lifted into place.

The stern casting is set to the proper height by checking the height of the water line on the casting from the ways. It is set on declivity by plumbing from the aft face of the connection for the neck yolk to the top of the skeg. The plumb line should fall 3½" aft of the center line of the lower rudder bearing. The casting is also checked port and starboard with a plumb line to see that is is vertical. It is set longitudinally with reference to the midship line by measuring from the bulkhead reference points which have been carried aft from the midship line. The fact that the distance from

Forepeak in Place.



Top of Stern Casting and After Peak Framing.

the aft face of the propellor shaft hole to the forward face of bulkhead 166 must be 10-0", to accommodate the stern tube, must be kept in mind.

Cable guys are placed to hold the casting in place vertically and horizontally. As soon as the casting is in place double bottom section XAU is placed, bulkhead 166 is set, and the three remaining floors 167, 168, 169 are placed with the center line intercostal. Shaft pedestal No. 8 is set on top of XAU.

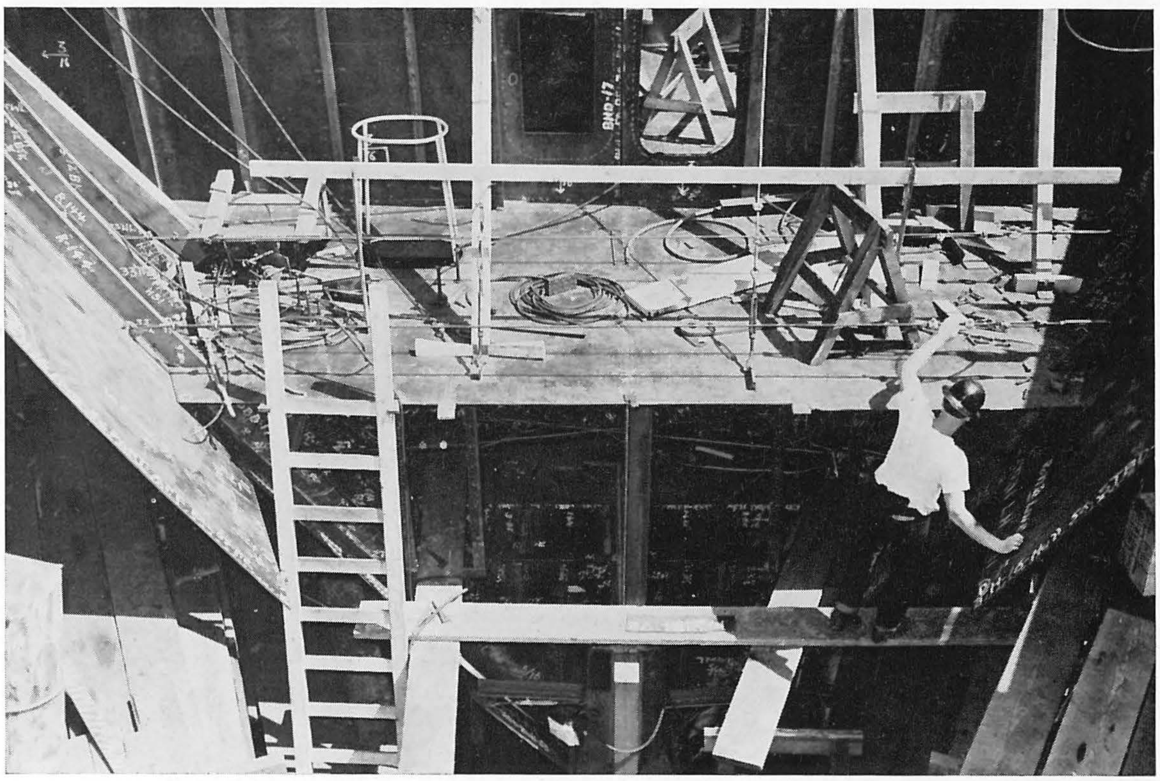
Bulkhead 156 has been set at the end of the tunnel. Side shell section B-14, with frames already bolted on is set. Then the tunnel recess top XBT is set on top of bulkhead 166, the shell frames, and bulkhead 156. After the tunnel recess top has been fitted and tacked, bulkhead 162 is set and the frames are placed on the tunnel recess top. Shell erection section No. 6 has been placed and the shell plates are individually hung. After C-14 and C-15 have been placed the rest of floors 167, 168, and 169 are set and the boss plate stiffeners are placed. All the rest of the after peak framing is completed to frame 174 and the shell plate is hung.

The second deck is brought aft to 174 and the upper deck is erected through XEEB, the transverse section aft of hold No. 5. After these sections are all tacked and the welding is well along, the fan tail is brought in from the skids and set.

The fan tail is set on center line and to the correct height. The correct height is determined by the height of the second deck at frame 174 and the computed heights of the upper deck at the aft end and at frame 174. Of these heights, the second deck is the most important since the steering gear sets on it.

Shores are placed under the fan tail. In addition, it rests on the upper end of the casting and on the side shell plates. Cables are attached to the top of the deck on the fan tail and run over timber piers on the upper deck to anchor clips at the hatch of No. 5 hold. When all the adjustments have been made, the interior framing is welded together and the outside shell is fitted and tacked.

In the near future when additional sub-assembly area is available, the entire after peak will be sub-assembled in several large sections and erected on the hull.



Second Deck in Place at After Peak.

This manual was prepared as an outline of the methods used by the California Shipbuilding Corporation in its efforts to build ships rapidly to meet the wartime demands for more ships in the shortest possible time. It is sincerely hoped that the data presented may help others to solve similar problems.